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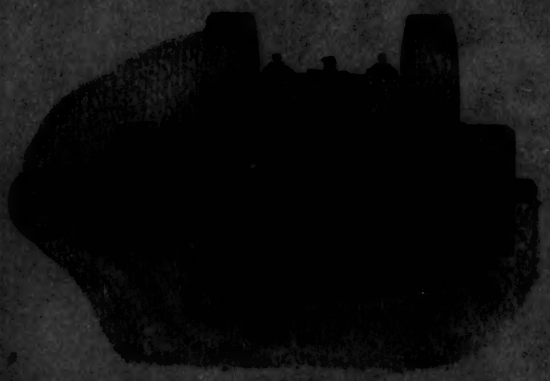

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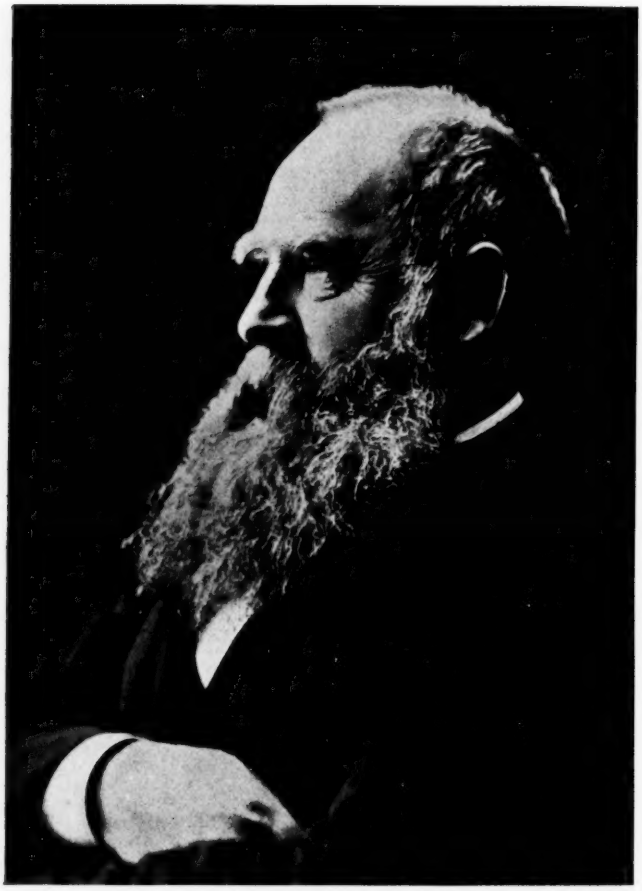
ERRATA FOR VOLUME VII

Page 49 line 27, for uredinospores read urediniospores.
Page 113, 114, and 115, for *Corticum* read *Corticium*.
Page 113 line 9 and page 114 line 4, for *ochraleucum* read *ochroleucum*.
Page 132 line 5, for *Cephaleurus* read *Cephaleuros*.
Page 134, for Illinois University read University of Illinois.
Page 184 line 7, for frum read from.
Page 193 line 1, for 30 read 50.
Page 208, section 6 of summary, line 3, for diseases read diseased.
Page 350, legend for figure 3 should read *Zygosporium oschioides*.
Page 369, 370, and 371, in table headings for uredinospores read urediniospores.
Page 376, table 1, column F, for 26* read 26.
Page 386 line 10, for Tomasski read Pomasski.
Page 390 line 12, strike out comma after water.
Page 418 line 1, after cane insert disease.



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F. KØLPIN RAVN

WITH PORTRAIT, PLATE I

The introduction of "hot-water treatment" is one of the most important steps forward in practical plant pathology, for it means a new principle both from a theoretical as well as from a practical point of view. Therefore it will surely interest the readers of PHYTOPATHOLOGY to become acquainted with the originator of the method, because in it we find an example of progress due to a man from practical life, who had scientific qualifications as well, and the ability to carry on independent research.

Jens Ludwig Jensen was born January 9, 1836, near the little town of Odder in the Danish province of Jutland, where his father was forester. In 1855 he passed a normal school examination and later supplemented his education by studying natural science. He taught school until 1872. In 1868 he started a weekly agricultural magazine, of which he remained the editor until 1880, and from 1879 until his death, he was the publisher of a widely circulating advertiser.

In 1872 Jensen resigned his position as teacher, and together with a colleague started a company for selling scientifically tested seed. This has had a great influence on the development of modern agriculture in Denmark. He took part in the daily routine of the business until 1881, and remained one of its directors until 1896.

Jensen never held any official government position but he managed to arrange his practical affairs in such a way that he could spend much time in study, and in 1881 he organized this work as a private statistical institute which he called Bureau Ceres. Its object was a systematic collecting of observations made in practical agriculture and an experimenting both in field and in the laboratory, which he had equipped in his private home. Although many of Jensen's methods were primitive,

yet his work is so exhaustive and original that his investigations of potato-late-blight fungus (*Phytophthora infestans*) and smut in cereals are among the most important contributions to our knowledge of these diseases.

Jensen's incentive for investigating the potato disease was the work done by his company in introducing new varieties of potatoes into Denmark. In the years 1878–1881 more than one thousand experiments were made in all parts of the country and while inspecting these Jensen had an opportunity of studying the appearance of the disease under various conditions. This suggested infection experiments in which he studied the spread of the infection from the leaves to the tubers and more particularly the ability of the soil to retain the spores of the fungus by filtration.

In 1882 Jensen published his experiments which resulted in the development of a method, "protective moulding," to prevent the tubers from infection. He discovered, too, that by postponing digging for two weeks after the wilting of the top, tubers otherwise subject to late attacks of the disease might be kept from infection.

In June 1882 Jensen began his important experiments concerning the influence of temperature on the development of the fungus. He discovered among other things, that this could not grow in a temperature of under 5°C. or over 24°C. Therefore the storage temperature of potatoes during the winter should never go higher than 5°C. These experiments gave Jensen the clue to understanding why the fungus attack is severe only in temperate climates, and he formed an hypothesis for explaining why the potato disease was not observed in North America and Europe before 1840. First then was the development in the means of transportation such that the potatoes from the plateau regions of South America, the original home of the potato and the potato fungus, might be carried so quickly through the tropical zone that the hyphae in the tubers did not die on the way.

In October 1882 Jensen succeeded in demonstrating that the hyphae and spores which were found in and on the diseased tubers could be killed by applying a temperature of 40°C. for four hours to the potatoes without affecting their germinating power. The heat must be applied as hot air for the germinating power suffered too much when the tubers were immersed in hot water.

In 1883–1884 Jensen published his method for disinfecting seed potatoes by heat. When this was used it was possible to prevent the primary attacks of the disease and to delay the secondary attacks at least one to two weeks.

Until bordeaux mixture appeared for the first time in 1886 as a preventive of disease, Jensen's system for fighting the potato fungus was the

best established method both practically and scientifically. In 1886 his work received recognition from La Société Nationale d'Agriculture de France, and he was awarded the large gold medal of the society.

In 1885 Jensen began to investigate smut in cereals, and by means of cross-inoculation experiments he succeeded in demonstrating that the old well-known species *Ustilago segetum* should be divided into four varieties which he named, *tritici*, *avenæ*, *hordei nuda*, and *hordei tecta*. The distinctiveness of these varieties was later confirmed by the mycological research of Rostrup, Brefeld, and Kellermann and Swingle. These infection experiments made it appear most probable that smut on barley and oats was caused by infection during the blossom period and that the smut spores (or hyphae) are to be found under the glumes in the ripe kernels. The importance of the rôle played by infected seed was further demonstrated by experiments proving the impossibility of infection through the soil and manure.

In 1887 and 1888 the most important experiments in disinfecting seed were published. Jensen compared the chemical remedies proposed by others (copper sulphate, sulphuric acid, quicklime, salt) with the hot water treatment he himself had found. He first applied hot air during a long period as for the potato fungus, but the results were for the most part unsatisfactory. However, an experiment made in the summer of 1887 in treating oats with hot water, circa 55°C. for five minutes, resulted in killing the smut without affecting the germinating power of the oats. This experiment forms the starting point for the development of the "Jensen hot-water treatment."

Jensen now made this interesting observation: Smut in barley is not to be killed by the same treatment as smut in oats, but if damp barley seed has been subjected to a temperature of 53°C. for five hours in a corked bottle the smut disappears. Jensen explained this phenomenon by supposing that a five minutes' immersion in hot water was insufficient to moisten the smut germs hidden in the seed and that they therefore were treated in a dry condition which could not occasion their death. By the slow heating of wet barley the moisture had time to penetrate and soften the smut germs and these were therefore killed by the temperature applied. If this were true Jensen thought that smut on barley could be prevented by soaking the seed in cold water and then applying the usual hot-water treatment for five minutes. Experiments made in 1888 proved the truth of this theory.

As we see, Jensen had now discovered two variations of a method according to which all forms of smut on cereals might be fought. He also proved that hot-water treatment could be used for smut on Bromus and Arrhenatherum and that it might be used as a preventive measure against certain types of damping-off in sugar beets and mangels.

Jensen's method won and deserved much recognition both in Denmark and abroad. However, it was a great disappointment to him to see that many farms which had introduced the method abandoned it later. It was too complicated for general practical use where no steam was available. Nor was he successful in his attempt to form a company for building a factory for applying the hot-water treatment of cereals on a commercial scale.

After this Jensen discontinued his work with the hot-water treatment and devoted himself to experiments with chemical remedies. Among these he preferred potassium sulphide, first tested by Kellermann and Swingle. This substance was the main ingredient in the so-called Ceres-powder, manufactured by Jensen and placed on the market in 1895. The last years of his life until his death, August 10, 1904, were largely devoted to experiments with this remedy and agitation to bring it into practical use.

During the years since Jensen's death the hot-water treatment has again come to the front. In connection with many of the Danish dairies and breweries, cooperative institutions have been established for disinfecting seed with hot water. During the past year several seed firms have built factory plants for the hot-water treatment in combination with a plant for drying the seed. The seed which has been thus treated is sold with a guarantee for its freedom from smut and leaf-stripe disease.

THE PENETRATION OF FOREIGN SUBSTANCES INTRODUCED INTO TREES

W. H. Rankin

With One Figure in the Text

Meyer[1] in 1808 succeeded in introducing a dyeing liquid into the roots of a small tree by cutting the stem and immersing the upper part of it in the liquid. The solution penetrated after some time into all the roots with the exception of their tips and the slenderest rootlets.

Boucherie[2] about 1840 patented his method of preserving timber for building purposes. He made a shallow groove around the tree and covered it with a belt. The space under the cloth was then connected with a barrel containing the preserving liquid. The solution was absorbed and ascended to the branches and leaves. Later, he modified his method. A canal two centimeters in diameter was made through the stem and from the latter cuts were made with a saw on both sides as far as possible without allowing the tree to fall over. The liquid was distributed up and down the stem. The area saturated, however, decreased rapidly in breadth in the downward direction. He states that the best season for thorough penetration by this method is autumn. It is doubtful as to the meaning of the expression "thorough penetration" since he further states that if there are hard knots or rotten spots at the base of the tree the whole strip of wood above them did not become saturated at all and the same was true with the central part of the core of deciduous trees.

Hartig[3] introduced colored solutions into the growing stems of trees. He bored two holes at right angles to each other in the trunk and introduced the colored solution into them. It was carried to the top of the tree but in transverse sections made of the trunk the coloring of the wood was not uniform. Only those vessels directly above the canals were colored, forming a cross in the sections.

[1] Meyer, J. C. F. Naturgetreue Darstellung der Entwickelung, Ausbildung und des Wachsthums der Pflanzen und der Bewegung und Functionen ihrer Säfte. Leipzig. 1808.

[2] Boucherie, M. A. Mémoire sur la conservation des bois. Annales de chemie et physyque **74**: 113–157. 1840.

—— Nouvelles recherches sur la conservation des bois. Comptes Rendus **12**: 337–339. 1841.

[3] Hartig, T. (Discussed by Shevyrev 1903: 6–7, but the direct citation to Hartig is not given.)

Sachs[4] in experiments on the rate of ascent of sap in woody plants used lithium nitrate. He allowed the plants to absorb this through the roots and found the lithium present at intervals along the stem and at the tips of the branches. He performed laboratory experiments in which he showed that such a substance as lithium would progress in the stem almost as rapidly as water itself, while solutions which dye the cell walls along its upward course do not rise nearly so rapidly nor so far, since they are largely filtered out.

Shevyrev[5] was the first to utilize the original negative tension of gases in the tree as a force for distributing the introduced foreign substance. He attributes the failure of Hartig and others to get penetration, except immediately above the incised vessels, to the neglect of this factor. His method was to attach a funnel or half-funnel to the tree, fill it with water and then make an opening in the tree with a chisel or auger, underneath the surface of the liquid. As a modification of this he devised a metal tube which was previously connected with a reservoir containing the feeding solution. This was forced at one end into the bark. The other end was closed with a rubber stopper through which a bit was inserted. Thus when the boring was done the solution from the reservoir penetrated immediately into the wound and the sucking power due to the negative tension of the gases in the tree was utilized to pull in the solution. He states that by this method the dye permeates not only the aerial but also the radicate parts of the plant. As to the results, he states: "The absorbed liquid had risen to the top and colored all the veins of the leaves and even the veins of the berries on the grape vine. The dye could be detected five feet below the surface on all of the roots of the birch, apple and ash trees. Thus the first part of the problem is solved; we can introduce a liquid in a desired quantity into all parts of a tree." Further he states: "The vessels incised in the liquid, absorbed and distributed it to all parts of a living tree. Only the pithy, dead portion of the tree was not saturated with the liquid although its absorption by the rays occurred (with an oak). The liquid entered the roots as well as the leaves, twigs and fruit." The data given for each tree fed do not indicate that he obtained anything more than the saturation of the sap wood and bark

[4] Sachs, J. Ein Beitrag zur Kenntniss des aufsteigenden Saftstrom in transpirirenden Pflanzen. Arb. bot. Inst. Würzburg **2**: 148–184. 1878.

[5] Shevyrev, Ivan. (Extraradicate nutrition of diseased trees with the aim of curing them and destroying their parasites.) M. Z. and G. I. Forestry Dept. Report to Forestry Department about injurious insects, pp. 1–51. 1903. (Reprinted from Selsk. Khoz. i. Lyesov. 1903: 58–103.)

—— (Supplements to the "Extraradicate nutrition of diseased trees with the aim of curing them and destroying their parasites".) Zemledeltcheskala gazeta (Agricultural Gazette) Nos. 3, 4, 5, 6. 1904. (Reprint consulted, pp. 1–13).

of root and stem and the leaves, for he mentions specifically that the medullary rays in the case of a single oak were colored.

Roth,[6] Goff,[7] Mangin,[8] Mokrzecki,[9] Bolley,[10] Simon,[11] Fron,[12] and others have fed trees with various types of solutions, including colored and nutritive substances. The majority of them have used nutritive salts or poisons in anticipation of curing physiologic ailments or inhibiting plant pathogenes and insects. No accurate data are given on the penetration except that the solutions in many cases were found to reach the leaves and some obtained penetration of the roots.

CHOICE OF SUBSTANCES FOR EXPERIMENT

It seems from the very nature of colored solutions, such as methyl blue and eosin, that they would not be suitable for determining accurately the greatest possible penetration obtainable by introducing a foreign substance. The staining quality is very helpful in tracing the rate and distance which the substance has advanced, but at the same time much resistance must be encountered by such substances and finally much of the original quantity absorbed will be adsorbed, filtered out and chemically united with the different plant parts which it will stain. The utilization of substances such as the lithium salts overcomes these disadvantages although the actual ascent is not visible. The salts of lithium are for the most part soluble in water, they are not used up rapidly in the metabolic processes of the plant and most important of all the minutest trace can be detected with the spectroscope. Lithium nitrate in solution was used in the experiments reported below.

[6] Roth, Carl. (A method for artificially feeding trees.) Chem. Ztg. **20:** 344–345, fig. 2. 1896.

[7] Goff, E. S. The application of artificial root pressure to recently transplanted trees. Wisconsin Agr. Exp. Sta. Ann. Rept. **14:** 272–282, fig. 4. 1897.

[8] Mangin, L. Sur la nutrition et la defense de la vigne par injection. Jour. Agr. Prat. **1898:** 918–920.

[9] Mokrzecki, S. A. (A new method of healing and nourishing trees.) Vyestvik Tavr. Zenistvo. nos. 11 and 12. 1903.

—— Über die innere Therapie der Pflanzen. Zeitschr. Pflanzenkr. **13:** 257–265, fig. 1–5. 1903.

[10] Bolley, H. L. (Artificial feeding of trees.) Report of the botanist. North Dakota Agr. Exp. Sta. Ann. Rept. **14:** 42–58. 1903. Ibid **15:** 33–65. 1904. Ibid **17:** 35. 1906.

[11] Simon, J. M. (Hypodermic injection in plants.) Jour. Soc. Nat. Hort. France. (Abs. in Gard. Chron. 3: **41:**8. 1907.)

[12] Fron, G. (Contributions to the study of the injection of nutrients into fruit trees.) Jour. Soc. Nat. Hort. France 4: **10:** 54–59, fig. 2. 1909.

FORCES AIDING DISTRIBUTION IN THE TREE

There seem to be three forces which must be depended upon for the rapid distribution of any foreign substance throughout a tree. (1) By taking advantage of the negative tension of the gases in a tree in the summer, when transpiration exceeds the intake of water through the roots, the solution containing the substance is quickly intromitted. Undoubtedly, the currents set up by supplying this ready access to a quantity of liquid serve to distribute the substance to a certain degree. (2) Most important of all, however, are the translocating streams of sap in the tree. The upward movement of raw sap will soon carry the substance to the leaves and the downward movement of the modified food materials in the phloem will undoubtedly carry the substance back down to all parts of the bark. The constant translocation of materials between such active cells as phloem parenchyma and medullary ray cells will serve to distribute it in time throughout these tissues and the downward movement of modified food into the roots would also be expected to ultimately carry the substance through the root tissues. (3) Except by diffusion, which is a very slow process, the only movements which can be counted on to distribute the substance in the heart wood are the translocation currents in the medullary rays and the alternate withdrawal and renewal of the water in the heart wood. The water in the center of the tree is said to act as a reserve supply upon which the tree draws during the day in dry weather. The normal water content of the heart wood is again restored at night. It would appear then that such an oscillation of currents might serve eventually to distribute the substance throughout the wood.

In other words there is no reason to believe that a foreign substance introduced into a tree cannot penetrate to all parts provided it possesses certain properties in itself.

METHOD OF FEEDING

Ten chestnut trees varying from two and one-half to nine inches in diameter were fed. The trees were growing in the forest and had small crowns. Shevyrev's methods with slight modifications were used in these experiments. A half-funnel was attached to the tree with putty. The funnel was then filled with water and a one-half inch hole was bored under the surface of the water with a brace and bit. The hole was bored to reach the center of the tree. A one-gallon bottle containing the lithium nitrate solution had previously been suspended so that the botton of the bottle was slightly higher than the hole in the trunk. The solution was then connected with the tree by means of a siphon, made of glass

and rubber tubing, one-quarter of an inch in diameter. In order to keep out air and prevent the leaking of the solution the apparatus illustrated by Rumbold[13] was used. The rubber siphon was connected to a short piece of glass tubing inserted through a one-inch rubber stopper. In attaching the siphon to the tree the solution was first started running and as the half-funnel was knocked from the tree the rubber stopper with the glass tubing of the siphon inserted was pressed against the tree so that it covered the hole. The end of the glass tubing was allowed to project into the hole about one inch. The rubber stopper was then held firmly against the tree by the use of wooden frames and a piece of No. 8 spring-steel wire. Thus the opening was perfectly sealed and after being once properly adjusted, needed no further attention. The glass siphon tube, reaching to the bottom of the bottle, was held in place by a loosely fitting stopper. By slightly raising this stopper a new supply of the solution could be poured into the bottle.

AMOUNT AND STRENGTH OF SOLUTION FED TO TREES

No attempt was made to keep careful records on the periodicity of the intake or to correlate it with any of the factors influencing the rate of intake. The accompanying table gives such data as were taken. Tree 1 had two days of clear, hot weather on July 15 and 16, when it absorbed

TABLE 1

Amount of lithium nitrate in liters of solution taken up by chestnut trees

TREE NUMBER	FIRST FEEDING			SECOND FEEDING		THIRD FEEDING	TOTAL	
	0.002 per cent			0.025 per cent	0.1 per cent	0.1 per cent	Liters	Grams
	Jy. 15–16	*Jy. 16*	*Jy. 16–20*	*Jy. 20–26*	*Jy. 26–A. 7*	*A. 13–0. 10*		
1	3	2	2	1	2	3	13	3.39
2		2	1.5	1.5	1	2	8	2.45
			Jy. 16–17	*Jy. 17–26*				
3		2	4	3.5	2	1	12.5	2.00
4					3	2	5	5.00
			Jy. 17–18	*Jy. 18–26*				
5		1	3	2	2	3	11	5.58
6					3	1	4	4.00
7						4	4	4.00
8						2	2	2.00
9						2.5	2.5	2.50

[13] Rumbold, Caroline. Report of the physiologist. Report of the Pennsylvania Chestnut Tree Blight Commission, July 1 to December 31, 1912, pp.45–47, figs. 39–49. 1913.

—— Methods of injecting trees. Phytopath. **5**: 225–229, pl. 13. 1915.

five liters of solution in twenty-six hours. Then followed a period of cloudy and cooler weather which caused a marked decrease in the amount absorbed by trees 1, 2, 3, and 5 during July 17 to 20. The largest amount of solution was absorbed immediately after attaching. Tree 2 absorbed two liters the first three hours and tree 3 absorbed five liters the first nineteen hours. However, the hole in tree 3 reached to decayed heart wood and the punky wood absorbed an unusual amount. The amount absorbed diminished rapidly after the first two days and in most cases practically ceased after the fifth or sixth day. Trees fed the second and third time did not take in as much as they did the first time. The increased strength of the solution used in the later feedings may have accounted for this. However, no detrimental effect on the tree was observed and the one-tenth per cent solution allowed the feeding of a sufficient amount in a shorter time. After the feeding on August 13, all the trees were allowed to stand until October 10 so that a chance was afforded for more complete distribution. The leaves were just beginning to fall when the trees were cut. A burning of the margins of the leaves occurred in the case of the smaller trees which had taken up as much lithium as some of the larger trees.

METHOD OF ANALYSIS OF TREES

The trees were cut as near to the ground as possible. Cross-sections about one-half inch thick were cut from the base, at the point of feeding and every ten feet up the trunk. A few leaves were taken from the tops of the trees. The sections were then seasoned. To obtain small blocks from these sections for spectroscopic analysis, a strip about one centimeter wide was sawed out along the diameter of each section. Where the bark was thick the cork layer was separated from one end of the strip, starting with the end which represented a point directly above or below the place of feeding. This was placed in a vial and labeled. Next the inner bark was split off from the wood. Then a small block about one-half centimeter thick representing the sapwood was cut from the strip. Similar blocks were cut from the strip at intervals of about two centimeters until the sapwood, inner bark and cork was reached at the other end of the strip. In this way it was considered that representative portions of the tree were obtained for analysis which would show rather accurately the penetration secured. The blocks were then incinerated in carefully cleaned crucibles in the bunsen flame. The ash was burned on a platinum needle in a colorless gas flame and the spectrum observed. The presence or absence of the red lithium line indicated whether or not the lithium had penetrated to the part of the tree represented by the block being analysed.

RESULTS

The results obtained were practically uniform. The blocks in which lithium was found are shown graphically in illustrations 1 to 9 in figure 1. In all of the trees except 3 and 6 complete penetration of the bark and sapwood was obtained at and above the point of feeding. In trees 3 and 6, for some reason, the lithium did not penetrate the sapwood on the side opposite the point of feeding. In all the trees except 1 and 4 the lithium had completely penetrated the sapwood and inner bark of the sections taken at the surface of the ground. In the case of trees 1 and 4 the solution had penetrated the bark and sapwood immediately below the point of feeding but did not appear in bark and sapwood on the opposite side. In trees 1 to 6, which varied in diameter from 5 to $9\frac{1}{2}$ inches, the lithium had penetrated the heart wood only in a few cases, notably the basal sections of trees 1, 3, 4 and 5 and the section twenty feet above the point of feeding in the case of tree 2. Tree 4 showed more heart wood penetrated than any of the others. In this tree the heart wood was decayed where the basal and breast-high sections were taken and the bark and sapwood of the basal section on the side opposite to the point of feeding was not penetrated. However, in the first two sections above the point of feeding the lithium had penetrated for at least two centimeters inside of the sapwood in sound heart wood. In the case of the trees of smaller diameter (7, 8 and 9) complete penetration of the entire wood and bark was obtained. These trees (7, 8 and 9) were from $2\frac{1}{8}$ to 3 inches in diameter and contained several layers of heart wood.

The leaves and twigs from the very tops of all the trees showed a large amount of lithium present.

CONCLUSIONS FROM DATA OBTAINED

From the above results it may be stated, therefore, that:

1. Lithium nitrate when fed to chestnut trees by Shevyrev's method penetrates to all places in the tree where there is an active translocation of food materials, that is, to all parts of the bark and sapwood above and below the point of feeding.

2. Complete penetration of the heart wood is obtained in trees less than three inches in diameter. In trees of greater diameter the process of penetration is slow and does not seemingly follow any definite rule.

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EXPLANATION OF FIGURE 1

The figures represent the strips of wood sawed out along the diameter of each cross-section cut from the trees. The blocks analyzed are shown in correct proportion as to size and position in the strip. Those blocks represented by shaded areas gave positive tests for lithium; those represented by white areas contained no lithium. All the figures are reproduced to a scale which equals one-fourth the size of the original sections.

The sets of sections are numbered according to the trees which they represent. The sections from each tree are lettered as follows:

A. Section from base of tree (at ground)
B. Section at point of feeding (breast high)
C. Section ten feet above *B*
D. Section ten feet above *C*
E. Section ten feet above *D*
F. Section ten feet above *E*
G. Leaves taken from top of tree

Where three blocks are shown at the ends of the strips they represent from the outside inward, cork, green bark and sapwood respectively. Where only two are shown they represent bark and sapwood.

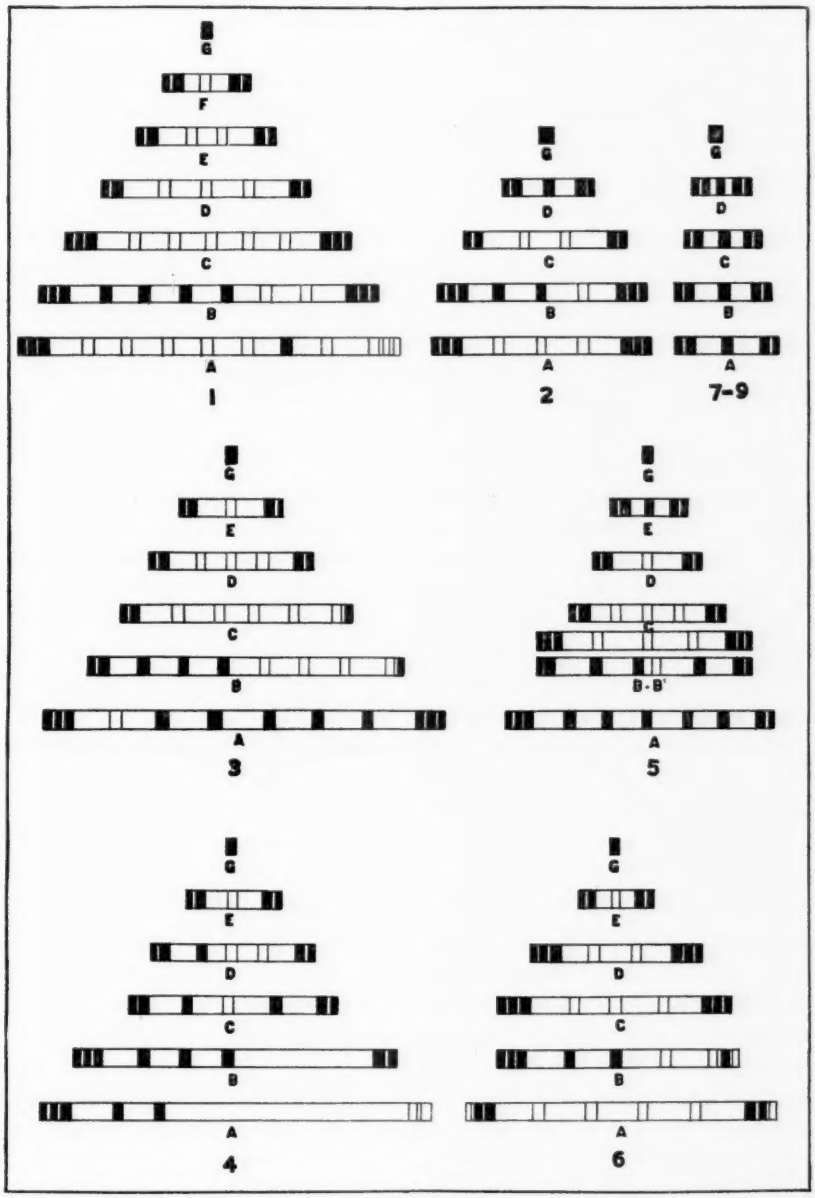

FIG. 1. DIAGRAMS ILLUSTRATING THE PENETRATION OF CHESTNUT TREES WITH LITHIUM NITRATE

THE GENERATION OF ALDEHYDES BY FUSARIUM CUBENSE

ELBERT C. LATHROP

The possibility of aldehyde occurrences in cultures of the organism from the Cuban banana disease was called to the attention of this laboratory by Dr. C. Rumbold because of the odor accompanying its growth. The possibility of aldehyde production by the fungus was further suggested by the work of the author on color production through interaction of aldehydes and certain plant constituents in connection with the investigation of humus bodies. One of the characteristics of the Cuban banana disease, which according to Smith[1] is due to the fungus, *Fusarium cubense*, is the purple, purple-brown, or blackish stain produced in the vascular bundles of the diseased banana plant. This Fusarium also reddens or purples various culture media. Numerous experiments carried on in this laboratory on the action of aldehydes of various chemical constitution in respect to their effect on plant growth have demonstrated that aldehydes are uniformly deleterious in action. The generation of aldehydes by *Fusarium cubense* might therefore account, at least in a measure, for its pathological action as well.

In regard to the generation of aldehydes by microorganisms Grey[2] has shown that acetaldehyde is a product of the action of *B. coli communis* on glucose under anaerobic conditions. That acetaldehyde is a product of the alcoholic fermentation by yeast was discovered by Roeser,[3] and more recently C. Neuberg and his co-workers have very fully studied the mechanism of this reaction. Neuberg and Hildesheimer[4] have shown, for example, that acetaldehyde is produced by the action of yeast on pyruvic acid, while Neuberg and Kerb[5] have been able to produce propionic aldehyde by the action of yeast on α-keto butyric acid.

That aldehydes are generated during the growth of *Fusarium cubense* on synthetic culture media was experimentally shown in the following way. Eleven 2-liter Erlenmeyer flasks, each containing about seven hundred cubic centimeters of Uschinsky's solution were sterilized in the

[1] Science **31**: 754–755. 1910.
[2] Biochem. Jour. **7**: 359–363. 1913.
[3] Ann. Inst. Pasteur **7**: 41. 1893.
[4] Zeit. physiol. Chem. **31**: 174. 1911.
[5] Zeit. physiol. Chem. **47**: 413–429. 1912.

autoclave and inoculated with a pure culture of *Fusarium cubense* on May 28, 1915. The flasks were set aside in a dark closet and the Fusarium was allowed to grow at room temperature until January 21, 1916, at the end of which time the Fusarium was still growing. The liquid culture media, which had darkened a little and which had taken on a slightly penetrating odor, was filtered from the sediment and growing Fusarium. The clear filtrate, alkaline in reaction, was slightly acidified with dilute sulfuric acid and the acid liquid was shaken out a number of times with ether which had been carefully freed from aldehydes. The aldehydes were removed from the combined ether extract by shaking with a freshly prepared, saturated solution of sodium bisulfite. The bisulfite solution was then acidified with dilute sulfuric acid, the sulfur dioxide removed by aeration under a long ice cold reflux condensor, and the volatile aldehydes, boiling under 75°, were separated from the solution by fractional distillation, and collected in about fifty cubic centimeters of ice cold distilled water. The aldehyde fraction so obtained was then treated with a little solid barium carbonate and redistilled in order to hold back any volatile acids. This distillate was tested for the presence of aldehydes.

A few cubic centimeters of the distillate when treated withSchiff's fuchsine aldehyde reagent gave a red color immediately. The distillate reduced ammoniacal silver nitrate solution, slowly in the cold, and very rapidly when gently warmed. The odor of the solution was that generally given by aldehydes, especially the lower aldehydes of the aliphatic series. On boiling a little of the solution with a strong solution of sodium hydroxide a pale yellow color was produced which disappeared on longer heating, and the odor of the solution strongly resembled that of lemon. This reaction is characteristic of propionic aldehyde, as distinguished from acetaldehyde or formaldehyde. All attempts to form the phenylhydrazone or the p-nitrophenylhydrazone compounds failed, probably owing to the small quantities of the aldehyde which had been obtained. The aldehyde in the remaining portion of the distillate was oxidized by means of dilute sulfuric acid and potassium permanganate solution to a volatile fatty acid, which was obtained in amounts too small to be identified by means of the formation of the metallic salts. By the method of obtaining the aldehyde the fatty acids obtainable by the oxidation with the acid permanganate mixture are limited to formic, acetic, propionic, butyric, isobutyric and trimethyl acetic acids. The odors of pure hot dilute solutions of formic, acetic, propionic and butyric acids are so sufficiently characteristic as to be readily distinguished from each other. Hot dilute solutions of these acids were then compared with the solution of the unknown acid and the odor of the pure propionic acid and of the unknown acid were so exactly similar that they could not be differentiated. This

would indicate that the volatile acid formed by the oxidation of the aldehyde is propionic acid. These reactions show that a volatile aldehyde is formed during the growth of *Fusarium cubense* on Uschinsky's solution and that this aldehyde may be propionic aldehyde, although the amount of the aldehyde which was obtained was too small to make absolutely certain its identification as propionic aldehyde. The solution remaining in the flask after the fractional distillation of the volatile aldehydes gave no reactions for aldehydes either of the aliphatic or aromatic series.

A badly infected banana stalk received from Trinidad by the Laboratory of Plant Pathology was examined for the presence of aldehydes. The stalk was finely chopped and pressed in a fruit press, and the juice so obtained was examined by the method given above, but no aldehyde reactions were obtained.

Since propionic aldehyde is a very volatile compound it is possible that appreciable quantities were formed during the growth of the Fusarium and escaped from solution. The author had hoped to take up this question and also establish absolutely the identity of the aldehyde formed, but circumstances do not permit of this at present. The observations made seemed of sufficient interest to call to the attention of other workers on this subject. The author wishes to thank Dr. Caroline Rumbold and Miss Florence Hedges for their kindness in growing the Fusarium and for furnishing the diseased and healthy banana stalks.

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DOES CRONARTIUM RIBICOLA WINTER ON THE CURRANT?

W. A. McCubbin

With One Figure in the Text

In the literature at the writer's disposal very little mention has been made of the over-wintering of *Cronartium ribicola* on the currant. In a few cases there has been a suspicion of over-wintering on this host but either the evidence was too meagre to be satisfying, or else other facts appeared later to explain the circumstances so that the general opinion at present favors the entire dependence of the currant stage on a yearly infection from the pine.

In some of the records, however, there are mentioned puzzling occurrences of the rust on currants, either at long distances from pines, or in circumstances otherwise so suspicious as to suggest that the fungus might have passed the winter on the currants themselves. Spaulding (5a) has mentioned, in connection with the distribution of the Peridermium stage that judging from analogy with *Cronartium Comptoniae,* the spores of which are similar in size and shape to those of *P. strobi,* it is probable that the latter would be blown only relatively short distances; but he records two cases in which no diseased pines were to be found near rusted currants. In another article the same author (5) lists a reference to an observation made by Nilsson in 1893, where rusted Ribes were found over three quarters of a mile from any pines.

Efforts have been made to settle the question experimentally, both by planting out badly rusted currants in a disease-free neighborhood after wintering, and by inoculation with over-wintered spores. So far as is known the latter method has given only negative results. The former method was employed by Stewart and Rankin (9) using five hundred rusted currant plants. None of these developed any rust during the succeeding summer, and the conclusion is drawn that the fungus rarely, if ever, over-winters on the currant. In 1914 Spaulding (6), in recording the negative results from similar experiments with two hundred plants, says, "The practical conclusion is that Ribes plants do not carry the fungus over the winter and that an outbreak of this disease on Ribes is to be attributed to the presence of neighboring white pines which have the blister rust."

In a former article (3) the writer has detailed some of the circumstances of the Ontario outbreak which engendered a suspicion that the rust in question might have passed the winter on currants, and in the work with this disease in 1916 additional evidence has appeared to strengthen this suspicion. The evidence at present available can not be considered sufficient to establish the point beyond question, but it is important enough to be worth careful consideration.

In the discussion following several points which have a bearing on the question are considered: (1) A hypothesis to account for the various phenomena observed. (2) Agreement of this hypothesis with known conditions in other rusts of a similar nature. (3) The general and irregular appearance of the currant stage over large areas in which there is reason to believe no pine infections are responsible for the disease. (4) Special cases, where rust has occurred on currants which are far distant from any possible source of infection. (5) The occurrence of currant rust in one instance on two out of four plants in a plantation in which the same four plants, and these only, were badly diseased in the preceding year. (6) The occurrence of a case of currant rust on plants set out in a rust-free district in order to test over-wintering.

1. HYPOTHESIS TO ACCOUNT FOR VARIOUS PHENOMENA OBSERVED

On account of the difficulty arising from the loss of all the currant leaves in the fall, thus separating the fungus from its host, no satisfactory hypothesis has been brought forward to account for suspected cases of hibernation. Spaulding (1911) has suggested the possibility of this hibernation, and has put forward the idea of a hibernating mycelium, justifying it by reference to observed cases where pustules of Puccinia occurred on currant shoots. The presence of *Cronartium ribicola* in such suspicious locations does not seem to have been established, although the same author (5a) records the finding of the telial stage of *Cronartium ribicola* on petioles and stipules of Ribes.

Judging from observations made during the last two years, the only hypothesis which seems to account for all the observed phenomena in connection with supposed cases of wintering over, is the hibernation of the mycelium in infected buds.

A feature of the disease previously mentioned by the writer (3) has an important bearing on this phase of the question: Early and complete defoliation by the rust, followed by a secondary production of leaves, due to the premature opening of winter buds. It has often been observed that such secondary leaves are also rusted, even when they are only partially opened, and considering that the incubation period of the fungus

is from ten days to two weeks or more, it must be evident that infection can take place very close to the bud stage, perhaps as soon as the bud scales are parted enough to expose the young leaves within. Now in the case of a shoot producing secondary leaves in this way, the terminal bud opens first and makes most growth; the one next below it opens to a lesser extent; and those farther down exhibit diminishing degrees of activity, until towards the base of the shoot buds are found which still remain in a quite dormant condition. It is true that leaves produced in this way from buds opening late in the fall are killed by the first severe frost, and often several of the uppermost buds also perish, but some of these forced buds, without doubt, are able to survive the winter.

The fact that each shoot producing secondary leaves has its buds arranged in a series extending from the fully opened condition to the dormant state, shows that there is ample opportunity for such a favorable combination of circumstances to occur, while the actual presence of the rust on very young leaves is evidence of the capability of the fungus to infect at this season of the year. The only step that need be taken outside the realm of fact concerns the assumption that an infection can take place early enough in the development of a bud to still leave it capable of passing the winter.

The field conditions demanded by the above hypothesis are quite adequate for the purpose. The early defoliation mentioned is general in some plantations, and in a large percentage of others a smaller or larger area of plants lose their leaves in midsummer on account of rust starting from one center. The total number of such cases where secondary foliage has been produced is many times the number of suspected cases of wintering-over, so that even allowing for a lack of infection in some instances, dying out of the mycelium in winter, and so forth, there still remain several times the number of plantations or parts of plantations required to explain the observed outbreaks of the rust.

In this connection it may be noted that the climatic conditions of the Niagara Peninsula are extremely mild for the latitude; the autumn is long and open: in the last two years roses have been in bloom in November; the temperature in winter rarely falls below —12°F., and there is an early start of growth in the spring. Under such conditions the persistence of the rust on currant foliage until late in the fall, and its ready occurrence on the secondary foliage, is not a matter of wonder. In addition the buds are advanced in this mild fall weather far beyond the stage at which they usually go into the winter in other localities. Perhaps the less severe winters might also permit the mycelium to remain alive in infected tissues in a manner that would be impossible in colder localities.

2. AGREEMENT OF HYPOTHESIS WITH ANALOGOUS CASES

The view that the mycelium of the fungus might successfully pass the winter in currant tissue is open to no *a priori* objection. What is the constant habit of the fungus in the pine might well become a temporary or occasional happening on the other host. In this connection it is scarcely necessary to point out the known habits of other rusts under like circumstances, but the recent work of Meinecke (4) on *Peridermium harknessii* has a peculiar interest here. In summarizing this work he says, "In California *Peridermium harknessii* and *Cronartium Quercuum* are to a high degree independent of each other;" and again, "*Cronartium Quercuum* over-winters on *Quercus agrifolia;* new urediniospores form in spring around the old, dead sori on old, living leaves, and infect the young leaves." He believes that since the crop of new spores is formed around the old dead spots, that therefore the mycelium must over-winter in the leaf tissue. The same over-wintering of the mycelium has been found by Mains (2) to take place in *Coleosporium Solidaginis,* the perfect form of *Peridermium acicolum.* In this case the pustules of the fungus were found to arise in spring in the rosette leaves of the Solidago host, in which the mycelium had apparently over-wintered. He was able to prove this point by sectioning the leaves, and finding therein the rust hyphae in limited areas.

3 AND 4. APPEARANCE OF CURRANT STAGE WHERE PINE INFECTIONS DO NOT OCCUR

Owing to the suspicions that arose in 1915 concerning the possibility of over-wintering on the currant, a careful inspection was planned for 1916, in order to determine whether cases of early infection could be found, which were either so far away from pines as to preclude the possibility of pine infection, or which were close only to pines of small size, whose freedom from disease could be absolutely established. In general there are such numbers of large pines scattered over the whole of the Niagara Peininsula that, even should cases suspicious of over-wintering be found to occur on currants, the nearness of the other host would render these cases valueless from this point of view. In two areas, however, the pines were so few in number that an early appearance of the currant stage in them would be difficult to explain on the ground of pine infection.

One of these areas comprises that part of Grantham and Niagara townships included within the dotted line on the map (fig. 1), which it will be noted also records the position of all pine and currant plantations. In 1915 the rust in this area did not start from a particular center or centers

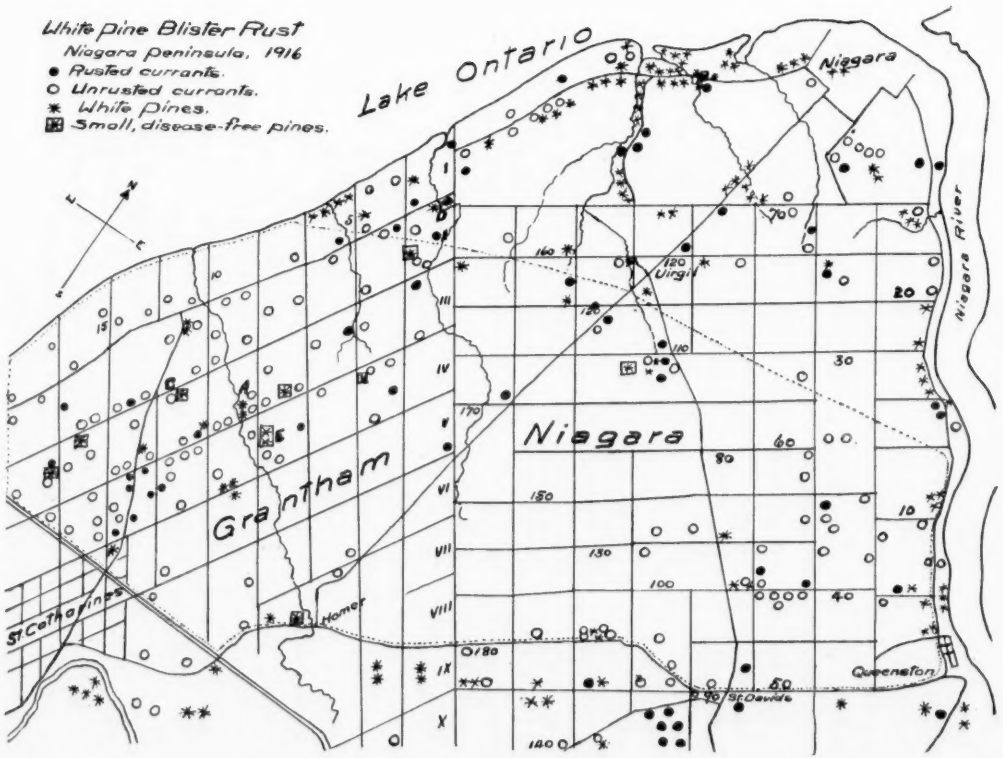

FIG. 1. MAP OF THE BLISTER RUST SURVEY IN GRANTHAM AND NIAGARA TOWNSHIPS, JUNE AND JULY, 1916

All pine groves and single trees, as well as all black currant plantations are recorded. Scale, two miles to the inch.

and spread outward therefrom, but it appeared simultaneously and irregularly over the whole district, totally without reference to the few pines to be found there. In 1916 the very same irregular occurrence was noted. Except in the Secord case hereinafter mentioned, there were nowhere any signs which would indicate pine infection; the infection areas in the plantations of currants were usually few, often only one or two; in no case was early infection general over a number of adjacent plantations, or even plentiful in one; and in most cases the only pines that could be suspected were more or less surrounded by disease-free currants.

Of the twenty-nine cases of currant rust (plantations) found in the area indicated, sixteen were so situated as to be regarded with strong suspicion. Eight of the sixteen are over a mile distant from any pine which could possibly be a source of infection, and in all the twenty-nine, except in the Secord case noted below, the rust started without any apparent reference to the pines in the neighborhood. Eleven of the twenty-nine cases originated on either one or two bushes in a plantation, and in all of these eleven the primary source could still be distinguished on the early leaves of the shoot. In sixteen other cases of the twenty-nine the origin from a similar small beginning was evident, but owing to lack of certainty in these cases they are not included as evidence.

Three of the cases occurring in this area deserve special mention on account of their typical character, and because of the strong evidence they bring on the question.

No. 1, Lot 17, Con. 3, Grantham. In this plantation there were present on July 6, two badly diseased bushes, on both of which the early infection had started on the second leaf of the shoot and had spread from there over the rest of the bush and to the adjoining bushes only. There are about twenty young pines four hundred feet from these currants, but they have been examined several times in 1915 and in 1916, and are all entirely free from the disease. Aside from these the nearest pines are over a mile distant with disease-free currants intervening.

No. 2, Lot 5, Con. 3, Grantham. Here are four old black-currant plants in a somewhat neglected garden. On July 6 two leaves on one of them had very old infection spots, while around these on the bush secondary uredino-pustules were present. The other bushes were absolutely free from the rust. As may be seen by reference to the map, there are three lots of pines southeast of this place, and one northeast. All these are young pines and are free from any signs of the blister rust. This disposes of all the white pines for nearly two miles in every direction except one forty-years-old tree in Lot 164, Niagara Tp., which is one and a fourth miles distant.

No. 3, Lot 36, Niagara Tp. The map shows the infected plantation to be over a mile from any pines whatever. It is moreover in the center of a currant area of which it alone is rusted. On July 15, the disease was found at one end of this plantation and the outbreak was traceable to several very old spots on early leaves.

In the second of the two areas mentioned, which includes the townships of Willoughby, Crowland and Bertie, in Welland County, the conditions are exactly the same as have just been outlined for the Grantham-Niagara district. The 1916 infection is irregularly scattered over the whole territory without any reference to the pines. Out of 185 currant plantations examined here seventeen were found to be diseased, of which fourteen were suspected to be cases of wintering over. In four of the cases the currant rust was found from one to two miles from the nearest pines, and even then these pines were not under suspicion, being either themselves far from a source of infection from currants, or else having disease-free currants near them.

Although the evidence adduced has been confined to the rust outbreaks in these limited and favorable districts, it must be understood that the same conditions prevail in other parts of the peninsula, and it is only the near presence of so many pines in all these districts which precludes adding a large number of other cases of a like suspicious nature. Unless either the aeciospores or the uredinospores are carried by the wind to much greater distances than we are accustomed to think, or than our limited experiences would indicate, the occurrence of currant rust in this area in 1916 is very puzzling on any other hypothesis than that of wintering over on the currant.

In addition to the above there is another line of evidence which has a direct bearing on the problem of the origin of the yearly rust outbreak in the Grantham-Niagara area already mentioned. This evidence is derived from careful examinations made of cases in the district where young pines and black currants are growing in close proximity, and of these the most outstanding instance was on Lot 13, Con. 3, Grantham, which for convenience of reference is called the Secord case.

On the Secord farm there was a row of sixteen young white pines planted along the western boundary. These pines were obtained from a native wood-lot in the neighborhood, and were planted out in 1910. Running from a lane in the middle of the farm to this row of pines are 175 large black currant bushes in five rows. On the eastern side of the lane, and about ninety yards farther north, is a small nursery plot of evergreens, among which were included about 150 young white pines, planted in 1912, and obtained from the Provincial Forestry plantation in Norfolk County, where they had been grown from native seed.

Although the currants on this farm were badly rusted in 1914 there was no sign of the disease on either lot of pines that year. In the season of 1915 the pines were all examined four times (May 5, May 14, June 14, August 9), but nothing remotely resembling the blister rust was found. The rust appeared again on the currants in the course of the summer, but was late in making its appearance, and possibly came in from elsewhere. Another inspection of the young pines was made very early in the spring of 1916, with the same result as before: no sign of the disease could be seen.

Owing to the close association of the two hosts, and the known occurrence of the currant stage for at least the two preceding years, special attention was judged to be necessary in this case, and accordingly a further inspection was made on June 6 and 7. On this occasion there were found a large number of discolored swellings which were undoubtedly the early

TABLE 1

Total number of white pine blister rust swellings found June 6, 1916, in the Secord nursery and fence row and the age of growth on which they occurred

YEAR OF GROWTH	NURSERY	FENCE ROW	TOTAL	PERCENTAGE
1915	0	1[1]	1	0.5
1914	43	84[2]	127	71.7
1913	39	10	49	27.7
1912	0	0	0	0
Earlier	0	0	0	0

[1] Somewhat doubtful. A swelling below the end of a broken-off terminal branch.

[2] One of these produced the blisters noted above. It was located at the upper end of the internode developed in 1914.

stages of the blister rust, and which had developed so as to be visible since the former visit. Only one case of the blister stage was found: A small twig near the ground bore five small blisters. These had already shed their spores, but were still readily recognizable by the slit-like openings, remnants of the peridium, and by a few remaining spores. The pines were minutely examined over every part of the stems, branches and twigs, and all the swellings collected for study, after which the trees were destroyed. The collection of swellings was then carefully gone over in the laboratory, and a record was made of the age of the growth on which they occurred. Their position on the tree is given in tabular form below.

Since the two hosts are here so closely associated that the currant stage could hardly be present without causing some infection on the pine, we are enabled to form from this table some conclusion regarding the date of the first appearance of the disease in this particular locality. As no

pine infections have been found on any growth prior to and including 1912 it seems certain that there was no currant rust here before 1913 at least. It is, of course, possible that sporidia of 1913 might have infected twigs of 1911 or 1912, but if so it is hard to believe that all such infections are still dormant when later pine infections have developed regularly and vigorously on the same trees. This seems to hint at the absence of the currant rust here in 1913, but this part of the subject will be considered later.

Since the currants have been known to be badly rusted in 1914, 1915, and 1916, it is only reasonable to suppose that plentiful infections have taken place in each of these years on pines so favorably situated, a point which is well borne out by the presence of such large numbers of them on the wood of 1914. These must obviously have arisen after the wood was formed, and are therefore referable to the rust of 1914 or 1915. The above table, however, shows an entire absence of infections on 1915 twigs (save for one very doubtful and abnormal case), and since no swellings or other indications of the disease were seen here in 1915, although the pines were certainly subject to infection in 1914, it seems fair to conclude that during the season after infection the fungus produces in the twigs no symptoms of a visible nature.

If in addition to this year of dormancy it is assumed that the swellings formed in 1916 will reach the blister stage in 1917, it is probable that the disease in pine limbs follows a four-year cycle, which may be thus summarized: first year, infection in late summer or fall; second year, dormant period; third year, swelling and discoloration, with possibly pycnospores; fourth year, production of aecia.

This rule of development is not to be regarded as invariable. In some cases the dormant period may be extended considerably, and on the other hand cases are known where blisters have been formed in the second year after infection instead of the third. Under ordinary circumstances, however, this cycle is perhaps generally followed.

We may therefore consider the swellings included in the above table as having originated from infections of either 1914, or both 1913 and 1914. Since no record exists of the presence or absence of the rust here before 1914, we are unable to state that these pines were not exposed to infection in 1913. But if they were so exposed and infections resulted, we are compelled to give an explanation of the sudden development into the swelling stage of infections of two seasons, simultaneously in the spring of 1916. If currant rust was present in 1913 it is obvious that every one of a large number of infections made in that year must have remained dormant for two years, while on the self-same trees a still larger number starting in 1914 reached the same stage concurrently, after only one

year's dormancy. One might imagine that adverse weather conditions might bring about such a peculiar varation in the dormant period, but it must be noted that during the spring and summer of 1915 there were collected at Fonthill, some fifteen miles away, about two hundred pine infections, in all of which the swelling stage in both old and incipient cankers was abundantly active. Aside from this one would hardly expect *all* these cankers to be affected by weather conditions; some of them might be retarded but others more favorably situated would have followed the usual course, and would have appeared as swellings in 1915. It seems far more reasonable to regard all the swellings in the table as the result of a single year's infection, that of 1914. According to this view they have all followed the cycle indicated (with the exception noted), and are due to produce aecia in 1917. It would follow from this, that the currant rust could hardly have been present on these currants prior to 1914, the year it was first discovered here.

Since the Secord farm, (fig. 1, *A*), is very centrally situated in the township of Grantham and in the heart of a region thickly planted with currants, the absence of currant rust here is strongly indicative of its absence in the surrounding neighborhood. Additional evidence on this point is furnished by four other cases of a like nature in the same district, where pines of small size also grew side by side with black currants.

In the first of these, (fig. 1, *B*), a large currant field is 25 yards distant from a number of young native pines, on which no signs of the disease could be found in 1915, In October, 1916, there were found on fourteen of these pines thirty-eight cases of the blister rust swellings. Of these sixteen were on the growth of 1913 and twenty-two on that of 1914. None could be found on growth of 1915 and nothing was present on any wood prior to that of 1913.

In the second case (fig. 1, *C*) there were two young pines within six feet of the black currants. In 1916 these also developed swellings for the first time; of the five seen here two were on wood of 1913 and three on that of 1914.

In the third case (fig. 1, *D*), the few young pines were about fifty yards from a short row of black currants. The one case of pine infection which appeared here for the first time in 1916 was on a shoot developed in 1914.

The fourth case (fig. 1, *E*), disclosed only two pine infections on a dozen young trees which were within ten feet of a large but slightly affected black currant plantation. Both infections were on pine shoots of 1913 growth. There is some additional evidence here in the fact that this row of pines was transplanted to its present situation in the spring of 1914 from a hollow about four hundred yards from these currants. Since there were no other currants within a quarter of a mile of this hollow,

there is good reason to believe that the pines received their infection after they were transplanted, that is, in 1914.

In all the four cases just referred to the adjacent currants are known to have been diseased in 1914. Likewise the pines were in every case minutely examined in 1915, so that their freedom from disease until the spring of 1916 is well established. Since in every one of the blister cankers found in these four cases the disease has occurred only on wood of 1913 or 1914, and none have been visible till the spring of 1916, they agree in every way with the evidence obtained from the Secord case, and together with it give a very strong support to the view that the currant rust was not present in the Niagara-Grantham region before 1914.

The bearing of this conclusion on the question of wintering over is obvious. If the rust did not appear in this district until 1914, then according to the probable life-cycle of the fungus no pine infections could reach the blister stage and start new currant infection before 1917. It follows therefore that the currant rust of 1915 and 1916 in the area under consideration must be due either to spores carried for long distances by the wind or to a wintering of the fungus on the currants themselves. Since this area is about ten miles long by five miles wide, and is distant from the nearest area of infection (the Fonthill district) from ten to sixteen miles, any attempt to attribute all these rust outbreaks to wind-blown spores is full of difficulty. Aside from this there remains only the wintering of the fungus on the currants as an explanation.

Objection may be made to the above reasoning on the ground that in some instances aecia may be produced the second spring after infection instead of the third. It is probable that such cases are rare. The single instance of this sort that was met with in the Secord case was the only one out of 223 blister cankers collected in these two townships in 1916. The small branch on which it was found was protected by high grass, and had the puffed, swollen appearance which normally occurs when a small limb is stimulated by contact with the moist earth. It was evidently an abnormal case, and probably had undergone a forced development by reason of its peculiar conditions. The writer is of the opinion that such abnormalities would rarely occur in large trees, and as for the small pines, practically all of these in the two townships have been subjected to such a scrutiny that the possibility of their playing a part in the yearly outbreak is utterly out of the question. This is especially apparent when the extent of the early occurrence of the currant stage is taken into consideration along with the observed rate of spread from the infection started at the Secord farm by the abnormal blisters just mentioned. In this case the rust began about June 1, at the ends of the five rows of black currants. By July 6, it had progressed down the rows for a distance of

only two hundred feet, and two adjoining plantations distant two hundred and three hundred yards respectively, were still free from any sign of infection. By August 21, there was only a slight infection on these adjacent plantations. It is almost impossible to think that one small infection of this sort, or even a number of them, could have started such a widespread infection on currants as our survey disclosed.

Moreover, while an objection of this nature might be valid for the rust epidemic of 1916, it could hardly apply to that of 1915 which was of the same extent and in the same area. Assuming that the rust entered this district in 1914 any explanation of the succeeding year's outbreak on the basis of pine infection would require the production of the blister stage in the spring of 1915, from a blister canker started by infection during the previous autumn. Even admitting the possibility of such precocious development, the blisters formed in this way must either have been numerous and widespread, or the spores from one or a few of them must have been carried from five to ten miles. In the first case our careful examination of young pines must have disclosed some of them, at least; and in the second case the general and irregular occurrence of small outbreaks without any recognizable center of infection, together with the known behavior of the already mentioned outbreak of this nature on the Secord farm, are quite against any such explanation.

5. RECURRENCE ON SAME INDIVIDUAL

The hypothesis advanced above is capable of being tested to some extent by field observations. If the rust winters in buds forced into late growth by premature defoliation, then it should be possible to establish a connection between suspicious early outbreaks of the rust and the plants or small areas which were defoliated during the preceding summer; if these areas showing forced growth were marked in the fall and rust appeared in them in spring in a larger percentage of cases than in the ordinary parts of the field, the case for over-wintering would be very strong indeed. Such field work would necessarily have to be done in a district where the results would not be interfered with by the presence of too many pines.

Unfortunately no systematic effort has yet been made along this line. The small amount of evidence now in hand comes from three plantations which were marked as defoliated in 1915. Out of the three, two were subject to early outbreaks of the rust in 1916, while the third was free. In both of the two cases the infection was small and started from one or two centers within the defoliated portion. A perhaps more significant case came up in the field work of one of the inspectors. In one large

black currant plantation the inspector who covered the ground in 1915 reported only four bushes, adjacent in a row, as badly rusted, with but slight infection elsewhere on adjoining plants. These four bushes were seen at that time by the owner, and when the inspector of 1916 called here, the owner told him where to find these bushes, which were on the side of the plantation opposite a small tree. The only case of rust which could be found in this plantation was on one of the four plants mentioned. It is conceivable that spores blown from some other place might start an infection in this one spot, and there only, in two successive years, but it is so utterly improbable that one can scarcely avoid turning to the wintering-over hypothesis for an adequate explanation of the case.

6. Rust on transplants in a rust-free district

In a former article (3) mention has been made of a rust outbreak which occurred in a small plot of black currants set out in the spring of 1915 to test for hibernation. The one hundred currant bushes used were all badly rusted in 1914. They were divided into five lots, of which two were well sprayed with lime-sulphur, two were left unsprayed, and one was exposed to infection from rusted currant leaves wintered out-of-doors and suspended among the foliage in loose wire baskets. A locality was chosen for the experiment far away from any known rust area; this district had few pines and the freedom from rust of the few existing currants was ascertained during the fall of 1914.

The one case of rust which developed on these plants was on one of the sprayed plots. At the time of examination, October 18, it was still of very small extent, involving only one shoot of a single plant. There was a small original rust spot surrounded by about twenty others of more recent date.

Owing to the limited extent of the rust here so late in the season there was some hesitation in attributing it to a wintering of the fungus, and every other possible source of infection was given due consideration. The only one of these possible sources that had any degree of probability was the carrying of aeciospores to this place in an inspection visit made on May 24. At this date no currant rust had been met with but some inoculations with the aeciospores had been made in the laboratory on May 20. The writer did not do this work himself but was in the room at the time, and a few air-borne spores might have adhered to his clothing and have been thus carried to the field in question four days later. Improbable as this suggestion may seem, it is the only explanation on the basis of accidental infection which seems to be worth consideration.

On the other hand the wintering of the fungus on the currants themselves readily explains the case. The fact that the plants were well sprayed in spring is in perfect harmony with the hypothesis advanced. Even the late appearance and small spread of the infection, which would appear to be incompatible with wintering-over, need present no difficulty; it is well known that while *Puccinia graminis* may live independently of the barberry for indefinite periods, yet by undergoing its proper stage on this host its virulency on cereal hosts is much increased. It should not be too much to expect, then, that in the case of *Cronartium ribicola* the second successive seasonal generation on the currant should lack somewhat of the vigor it would possess after coming fresh from the pine. The results of the survey work in the Niagara Peninsula seem to hint at a confirmation of this view. A great many of the cases of currant rust observed here during the last two years have been in the type indicated: an old but very feeble rust center, which by the end of the summer had involved only a single bush, or at most a few adjacent bushes. Other explanations of this seeming lack of vigor are no doubt possible, but such a decadence is quite compatible with a hibernation hypothesis.

In concluding this discussion it is clearly recognized that the evidence submitted is inadequate to establish the point under consideration, but on the other hand it is considered that enough evidence has been adduced to warrant a strong suspicion of currant hibernation, and this suspicion holds even though the hypothesis tentatively put forward should prove to be untenable in the light of later investigation. In any case the evidence obtained serves to narrow the field of inquiry to a great extent; for the conditions outlined above are such that the question of hibernation clearly hinges on the distance aeciospores or uredinospores can be carried by the wind; if only for a mile or two, then wintering on the currant has almost certainly taken place in the area under consideration; if on the other hand the spores are borne eight or ten miles or farther, another explanation of the situation in this district becomes easily possible, although the question of hibernation is not even then altogether disposed of. In the absence of definite information concerning spore dispersal the question must remain open until a body of trustworthy evidence can be accumulated on this point, or until more direct evidence is available on other phases of the subject.

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THE INJURIOUS EFFECTS OF TARVIA FUMES ON VEGETATION

A. H. Chivers

The following article contains a brief description of the destructive effect of tar smoke on plants which the writer had occasion to study during the summer of 1914, together with a brief account of experiments carried on since that time in the laboratory, and under controlled conditions.

The tar compound which was in use for building purposes, and which seriously affected the neighboring vegetation, is sold under the trade name, tarvia. For melting the compound a single kettle was set up about sixty feet distant from the nearest corner, and three hundred feet distant from the farthest corner, of a garden which covered an area roughly a hundred and eighty feet square, and which contained both ornamental and crop plants.

A strong and constant wind carried the fumes over the garden for about four hours on the afternoon of August 10 and throughout the forenoon of August 11, during which time the leaves and stems of the plants became coated with a substance of a greasy nature.

The subsequent destruction of the plants was very rapid. The leaves soon curled and shrivelled, dried out and fell. At least twenty species and many varieties were affected. Poppies, *P. somniferum* Linn., *P. rhoeas* Linn., *P. orientale* Linn., candytuft, *Iberis amara* Linn.; marigolds, *Calendula officinalis* Linn.; azaleas, *Azalea viscosa* Linn.; sunflowers, *Helianthus annuus* Linn.; strawberries, *Fragaria* in varieties, and squashes, *Cucurbita pepo* Linn., and *C. maxima* Duchesne, were killed. Paeonies, *Paeonia* in varieties, were killed to the surface of the soil. Roses, *Rosa* in varieties; honeysuckles, *Lonicera tartarica* in varieties; currants, *Ribes* in varieties; raspberries, black raspberries and blackberries, *Rubus* in varieties, were defoliated, and in some instances were killed. Potatoes, *Solanum tuberosum* Linn., which occupied the greater part of the garden, were stunted and the yield was greatly reduced. All perennials showed the effects of the injury in the following season's growth.

BRIEF SUMMARY OF LITERATURE

Observations on the effect of vapor and dust from tarred roads, and smoke from melting tar on neighboring vegetation, have led to extensive

investigation of many tar compounds, and it has been found that while these compounds vary widely, the smoke and fumes from these are in general injurious to plants.

Gatin[1] investigated different substances used for the surface treatment of roads and his results tended to show that many trees, shrubs, garden plants and flowers suffered injury from the fumes given off by the tar, and also from the dust arising from the treated roads. The injury seemed to be proportional to the distance from the road, the amount of phenol in the compound, and the isolation of the plants. The effect was shown in the fading of the leaves which were spotted and blackened. The cells were plasmolyzed and the chlorophyll disappeared. Marked differences in resistance to injury on the part of some plants were noted.

Gatin and Fluteaux[2] found as a result of studies on leaves and branches of catalpa and locust that plants which have been submitted during the season to the dust from tarred roads had become considerably modified in respect to anatomical structure.

Mirande[3] made a study of the influence of the tarring of roads on plants, and concluded that the injury was done by vapors given off in considerable abundance during dry, hot weather. He stated that if trees and ornamental plants in cities are to be preserved the use of tar on roads should be made with care. The same author[4] investigated the effects on plants of a number of commercial products such as Carbonyle, Carbolineum and Carboneine, all of which contained creosote, and a number of which were used as insecticides. They were more or less injurious, causing the destruction of the green cells. He urged care in their application.

Griffon,[5] as a result of laboratory work covering three seasons, confirmed the conclusions of Mirande regarding the injurious nature of gases given off from tar when used in coating roads. From extensive observations

[1] Gatin, C. L. The effects of tarring roads on the growth of trees in the Bois de Boulogn. Compt. Rend. Acad. Sci. Paris. **153**: 202–204. 1911.

—— The experimental reproduction of the injury to plants by the vapors and dust arising from tarred roads. Compt. Rend. Acad. Sci. Paris. **153**: 688–690. 1911.

—— The tarring of roads and its effect on the neighboring vegetation. Ann. Sci. Nat. Bot., ser. 9, **15**: 165–252. 1912.

[2] Gatin, C. L. and Fluteaux. Anatomical modifications produced on plants by dust from tarred roads. Compt. Rend. Acad. Sci. Paris. **153**: 1020–1021. 1911.

[3] Mirande, M. The effect of tarring roads on plants. Compt. Rend. Acad. Sci. Paris. **151**: 949–952. 1910.

[4] Mirande, M. The effect on plants of certain substances extracted from coal tar. Compt. Rend. Acad. Sci. Paris. **152**: 204–206. 1911.

[5] Griffon, E. The influence of tarring roads on neighboring vegetation. Compt. Rend. Acad. Sci. Paris. **151**: 1070–1073. 1910.

he concluded that the probable injury to vegetation in the open country would be small.

Claussen[6] exposed plants to vapors of several commercial tars, and found that the various kinds of tar sold for building highways differed widely as to their effects on plants. The nature and extent of the injury were closely related to the concentration, thus depending on volatility and temperature, and that species of plants differed widely as to their susceptibility to the vapors. Certain recommendations were made in respect to the proper handling of such products.

Gabnay[7] gave a brief account of the injury to trees by tar used on the trunks as protection against the ascent of caterpillars, which involved not only the cambium but also the sap wood, and extended beyond the limits of the tarred areas. The injury was ascribed to the exclusion of air and the action of acids and salts.

Ewert[8] investigated the injury to vegetation by smoke-borne products, and reported a peculiar lacquered appearance on the upper surface of leaves of a number of economic plants, frequent rolling and crumbling of the laminae, and discoloration over part or all of the surface. Fruits and garden produce in such neighborhoods showed the effects. Controlled experiments showed that injury depended not alone upon the amount of material present in the atmosphere, but also upon the heat, dryness and isolation.

A case most similar to the one under discussion is recorded by Moore[9] as having occurred at Woods Hole, Massachusetts, when a collection of valuable roses was seriously damaged by smoke which resulted from the burning of a tar and gravel roof in the vicinity of the garden. The effect of the smoke began to be noticeable during the third day of the fire, and was indicated not only externally by the falling of the leaves and the scarring and marking of the young and tender stems, but also internally where large areas of growing tissue died and the contents of the cells were shrunken and distorted, the green coloring matter having been completely disorganized. All plants were affected, some were killed outright, and others so weakened that they became much more susceptible to the attack of fungous diseases.

[6] Claussen, P. The influence of tar, particularly that of tarred streets upon vegetation. Arb. Kais. Biol. Anst. Land. u. Forstw. **8**: 493–514. 1913.

[7] Gabnay, F. von. The pathological action of tar on plants. Centbl. Gesam. Forstw. **39**: 497–504. 1913.

[8] Ewert, R. Injury to vegetation by coal tar and other vapors, and protection therefrom. Zeitschr. Pflanzenk. **24**: 257–273, 321–340. 1914.

[9] Moore, G. T. Roses vs. Railroads. Rhodora **5**: 93–96. 1903.

The very complete bibliography of McClelland[10] also should be consulted in this connection.

RESULTS OF EXPERIMENTS CONDUCTED IN THE LABORATORY

It was soon found that the injury to plants by tarvia could be duplicated easily in the laboratory, and experiments have been made for the purpose of determining whether or not what seemed to be facts at the time of the accident would appear under controlled conditions. For this work begonias, Begonia in varieties; ferns, Adiantum, Aspidium and Pteris; wandering jew, *Zebrina pendula* Schnizl. and *Commelina nudiflora* Linn.; and geraniums, Geranium in varieties, were used.

In a comparatively short time after the plants were placed in the path of the fumes, the same greasy covering of condensed volatile substances which collected on the garden plants began to appear over the plant surfaces. Plants three to four feet distant from the source of the fumes showed an appreciable covering in about three hours.

The symptoms of injury were found to vary appreciably with the species. Leaves of begonias showed a characteristic sinking of the upper epidermis, at first in small, isolated areas, which gave a peculiar pocked appearance to the leaves. The pock marks gradually became confluent, and the entire area lost chlorophyll and turned brown. In the youngest leaves the first symptoms appeared as yellow spots, three to six millimeters in diameter, which when examined, were found in each case to be an injured area immediately surrounding a multicellular gland. Older leaves turned yellow over their entire surfaces and fell from the stem.

Ferns treated with the fumes withered and dried as if subjected to extreme heat. Geraniums showed a tendency of spotting. In general, however, the lower and older leaves turned yellow, those of medium age turned dark brown over the entire surface, while the youngest and only partially unfolded ones showed dark brown zones on their margins.

Experiments were performed with the purpose of determining whether or not the injury was due to the interchange of gases through the stomata. Species of begonias were particularly desirable for these experiments, since stomata are found only on the under surfaces of the leaves. Plants with a single stem bearing about ten leaves were used. The stem was wound with cotton and then with waxed paper. Some leaves were left unprotected. For other leaves cork masks were cut to fit the upper and under sides, the center of the upper mask having been cut away until only a narrow rim remained. These masks were then pinned in place so that the leaves were entirely protected on the stomatal surfaces, but exposed

[10] McClelland, E. H. Bibliography of smoke and smoke prevention. Mellon Inst. Indus. Research. Bul. **2**: 1–164. 1913.

on the upper surfaces with the exception of a narrow margin. The plants were placed so that the exposed surfaces faced the fumes. In all cases the injury was as marked and of the same nature as in the unmasked leaves.

An experiment was tried of painting onto the surfaces of the leaves with a camel's hair brush the volatile matter which condensed on the surface of the glass above the emanating fumes. It made little difference whether it was applied to the upper or lower surface of the leaf. The affected areas showed the same symptoms as those treated with the fumes. The painted spots became brown and finally dried and dead.

It was assumed from the first that the injury in the garden was due entirely to the effect of fumes on above-ground parts. To confirm this assumption, however, the pots were either wrapped in several layers of paraffined paper, or coated with paraffin and their tops covered with waxed paper. With plants thus protected the results recorded above were obtained.

SUMMARY

The results may be summarized as follows:

1. The fumes from the compound known as tarvia are highly injurious to vegetation.

2. Leaves whose surfaces were painted with the oily matter which collected on a cool glass plate over the emanating fumes showed the same symptoms of injury as did those treated with the fumes. This, together with other evidence, indicated that the injury was due in large part at least to the constituents of the volatile substances which condensed in the form of an oily coating on the surfaces of the plants.

3. Plants with no stomata on the upper surfaces of their leaves were protected in respect to all other surfaces, and so placed that only the upper leaf surface was subjected to the fumes. Such plants showed injury of exactly the same nature as did those with unprotected stomatal surfaces. This indicated that the injury did not involve, to any extent at least, the passage of gases through stomata.

4. In a sufficient number of experiments the soil and under-ground structures were protected from the fumes, showing that the injury was due to the action of the fumes on aerial parts.

5. The injury varied with the distance from the escaping fumes, the temperature of the melting tar, the age of the plant structures, and the species used.

DARTMOUTH COLLEGE,
HANOVER, N. H.

SOUR ROT OF LEMON IN CALIFORNIA*

CLAYTON O. SMITH

WITH TWO FIGURES IN THE TEXT

The fungus causing the decay described in this paper was first isolated some years ago from lemons which were originally infected with the brown rot fungus *Pythiacystis citrophthora*. Artificial inoculations made at that time on green lemons with a pure culture of the organism gave negative results, and no further attention was given to it until in 1915. The method of development, morphology and general characteristics of the fungus, noted at that time, were similar to those described in the present study. The decay has been found in many of the lemon packing houses of California and probably occurs more or less in all of them. The fungus is not known to have caused serious losses until the summer of 1915, when the unusually large crop of lemons made it necessary to hold large amounts of fruit in storage for a longer period of time than is customary, during which time considerable loss occurred in the packing houses and in transportation. It seemed to be especially infectious with fruit picked in the spring, being most commonly reported in May fruit. The fungus has also been found causing a rot of Valencia oranges in transit.

Several popular terms have been applied to this decay such as sour rot, slimy rot, watery rot. These terms are descriptive of different stages of the decay. The peculiar sour odor is so constant a characteristic and one so distinct from those of other decays of citrus fruits that the name sour rot is suggested for this decay.

Sour rot is a soft decay, during storage, of citrus fruit, especially of lemons. The tissue when infected quickly softens, but for some time may retain nearly its normal shape. It, however, changes to a straw color[1], later collapses, becoming more or less slimy with age, and at last is almost completely changed into a watery mass, which in the packing house often drips down into the lower fruit of the stacks. Because of these characteristics the grading and sorting of the fruit is very disagreeable. The softened areas of the fruit do not at first show any noticeable aerial my-

* Paper No. 38, Citrus Experiment Station, University of California, Riverside, Calif.

[1] Dauthenay, Henri. Repetoire de Couleurs, p. 31, No. 3.

celial growth, but later a short white (never glaucus), flaky (never very cottony), growth occurs and forms a thin, compact, often somewhat wrinkled, mycelial layer over the affected tissue. The fungus is infectious, readily spreading by contact to sound fruit in a way very similar to that of several other fungi causing rots of lemon fruits.

A microscopic study of the affected tissue, as well as of pure cultures, shows numerous spores of variable lengths. These spores frequently are flattened at the ends suggesting at once that they had a chain-like arrangement in growth. An examination of cultures of the fungus in petri dishes shows considerable aerial mycelium which is closely septate,

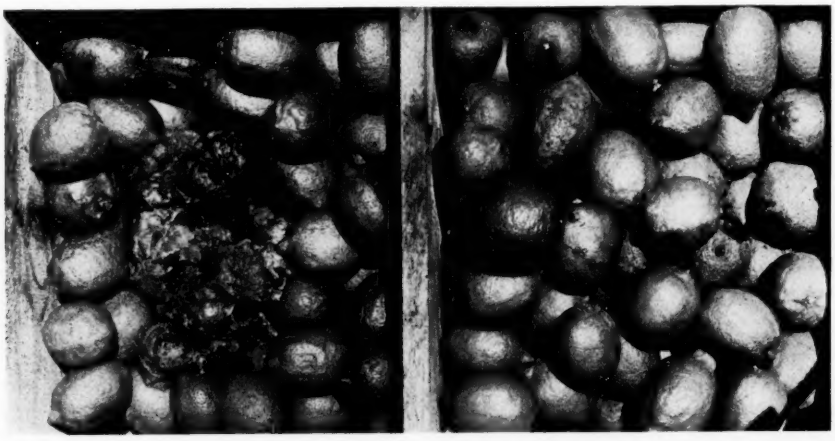

FIG. 1. SOUR ROT ON EUREKA LEMONS

The photograph shows natural infection as it is sometimes found in storage boxes in lemon-packing houses. The shrinkage in the part of the box having the rot is to be observed.

the individual segments being spore-like in appearance, and when placed in water readily separate as individual spores. The chains of aerial spores are simple or branched. The submerged mycelium is closely septate, especially when old. The individual segments readily separate from each other in water and function as spores. The spores measure 8–20 x 5–8 μ. They are oval to oblong, have obtuse often nearly square corners. When grown on certain media, as citrus fruits, oil globules and a granular substance are formed. The mycelium which measures 6–7 μ in diameter may when grown on a rich substratum like citrus fruits also contain granular matter and also possibly oil drops.

The fungus causing the sour rot is probably identical with the one origi-

nally described by Ferraris[2] as *Oidium citri-aurantii*. Saccardo and Sydow later transferred the fungus to the genus Oospora. Cultures of the sour rot fungus were submitted to Professor David R. Sumstine, Peabody High School, Pittsburgh, Pennsylvania, for identification, and he regards this species as belonging to the genus Oosporoidea,[3] a group of fungi that is now separated by some systematists from Oospora because of the slight differentiation between the mycelium and the sporophores. The fungus should now probably be called *Oosporoidea citri-aurantii* (Ferraris), but for the present will be designated as Oospora. The aerial mycelium of the sour rot readily separates into spores when mounted in water for examination, as does also the mycelium growing on the substratum. Sporophores and chains of spores are with difficulty distinguished from the mycelium.

Ferraris[4] found from his study and inoculations, that the fungus *Oospora citri-aurantii* caused an infectious soft decay of oranges. The individual points of infection increased in size and coalesced. A strong odor of fermented juice and a disagreeable taste of the fruit accompanied the decay. No aerial mycelial growth was at first visible, but under favorable conditions, a short very white, wrinkled mycelium developed, forming in contact with the substratum a gelatinous layer. The mycelium has a constant diameter of about 7 μ being described as being perfectly yellow and granular when growing in the orange tissue. The color of the mycelium of the sour-rot fungus as observed under the microscope when taken from artificially inoculated oranges, shows a slightly yellowish color but could hardly be said to be perfectly yellow. The size of the conidia as given agrees very closely with that of the sour-rot fungus. Ferraris recorded the size of cylindrical conidia as 13.5–19 x 7–7.5 μ; oval conidia 9–12 x 7.5 μ; spherical conidia about 12 μ.

Ferraris refers to certain other closely related fungi, causing rots of citrus fruits. Among these are *Oidium fasciculata* Berk., probably synonymous with *Oospora fasciculata* Sacc. et Vogl. and *Acrosporium fasciculatum* Grev., which is said to occur in decaying citrus fruits in Belgium, Great Britain, Italy and North America. This fungus differs from *Oospora citri-aurantii* in that the mycelium is at first white but changes to glaucus with age. *Oidium tigitaninum* was described[5] from California as a pow-

[2] Ferraris, T. Di un nuovi ifomicete parassita nei frutti di arancio. Malpighia **13**:. 1900.

[3] Sumstine, D. R. Studies in North American Hyphomycetes. The tribe Oosporeae. Mycol. **5**: 45–61. 1913.

[4] Ferraris, T. Loc. cit.

[5] Carter, C. M. A powdery mildew of Citrus. Phytopath. 5: 193–196. 1915.

dery mildew of Dancy tangerine. It differs in size, in shape of spores and in other morphological characters from the fungus under consideration.

Oospora citri-aurantii is closely related to *Oospora lactis* morphologically, a fact fully recognized by Ferraris, who found similarity in conidia

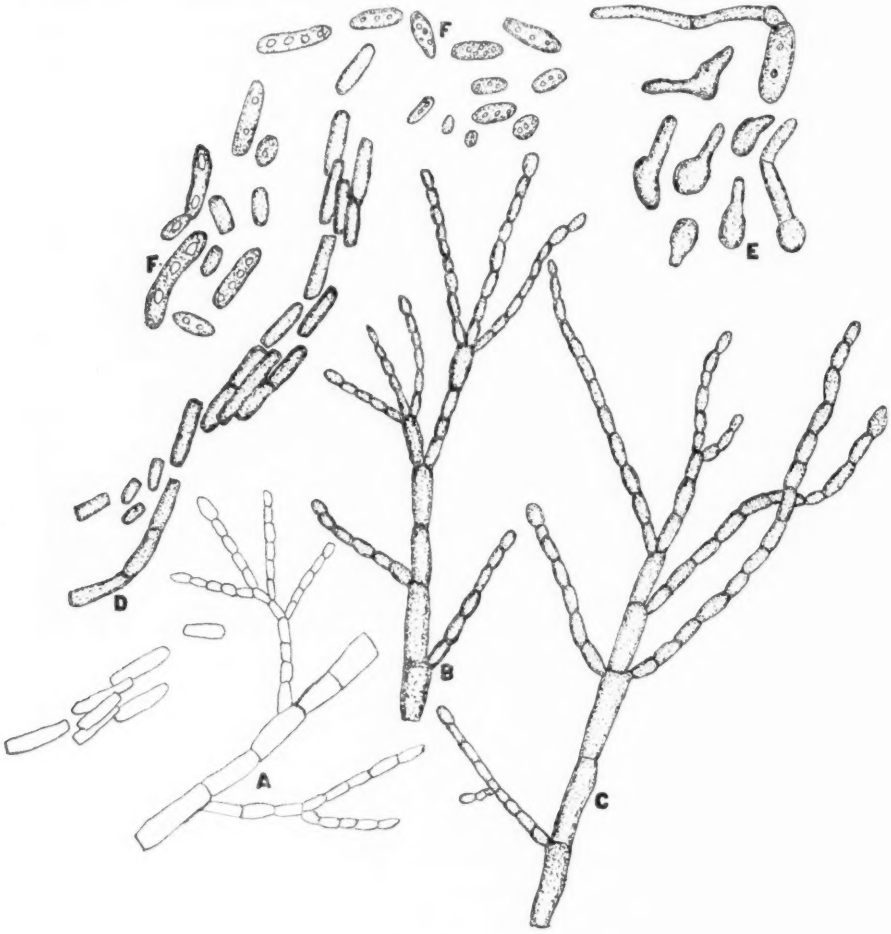

FIG. 2. SPORES AND MYCELIUM OF OOSPORA CITRI-AURANTII

A, *B*, *C*, aerial mycelium showing chains of conidia. *D*, mycelium separating into cells that function as spores. *E*, conidia, showing various stages in germination. *F*, old conidia showing oil globules.

germination, hyphal branching, and the manner in which the conidial chains are formed. He also mentions the enormous number of conidia which these two fungi are able to produce, especially when the mycelium

itself breaks up into spores. Certain differences have, however, been found between these two fungi.

Oospora lactis is probably a composite species into which a number of closely allied fungi have been placed by systematists. A culture of *Oospora lactis*, with which the sour-rot fungus was compared, was furnished by Mrs. Flora W. Patterson. This culture was isolated from oysters. A culture isolated from the same source was also received from Dr. Charles Thom.

Artificial inoculations with *Oospora lactis* from these two cultures and with the sour-rot fungus on citrus fruits showed that *Oospora citri-aurantii* is pathogenic, causing the fruit to begin to decay within a few days. *Oospora lactis* at first produces some mycelial growth on the injured tissues, but the mycelium does not appear to be able to attack the tissue adjacent to the injury and no actual decay takes place. These experiments were performed several different times in moist chambers on Eureka lemon. Navel orange and Dancy tangerine. No infection took place, although duplicate experiments on the same kinds of fruit with the sour-rot fungus gave positive results.

The reaction of litmus milk with the two fungi differs. The sour-rot organism caused no change in the reaction and probably made but slight growth. *Oospora lactis* showed an acid reaction and clearing of medium without separation of the casein.

The spores of the sour-rot fungus appear more regular in size, and more cylindrical than those of *Oospora lactis*.

Artificial inoculations were made by puncture with cultures of *Oospora citri-aurantii* on the following citrus fruits in moist chamber: lemons, oranges, grapefruit and tangerine. Positive results were secured in moist chamber, the rot beginning to show in forty-eight hours. The ripe or nearly mature fruit is more readily infected. Failure to infect the green fruit of lemons has frequently occurred. Inoculations on the twigs of a Eureka lemon gave negative results. Lemons showing the initial stages of the brown-rot fungus, *Pythiacystis citrophthora*, were atomized with a suspension of spores of the sour-rot fungus. Infection took place quickly in the brown rot areas and continued to increase as the former decay advanced. Eventually the surface of the lemons was coated with the sour-rot fungus. Sound fruit when inoculated with an atomized suspension of spores or when soaked for twenty-four hours in spore-laden water were but rarely infected and then probably only in some superficial injury. Infection of lemons with the sour-rot fungus evidently only takes place through some injury or from contact with infected fruit.

WHITTIER, CALIFORNIA

A DISEASE OF PECAN CATKINS

B. B. Higgins

With Two Figures in the Text

During the latter part of April, 1916, the writer's attention was called to an abnormality of the catkins (staminate) of pecans, *Carya illinoensis*, on the Experiment Station plats. Some, or in many cases, all of the flowers of a catkin were slightly distorted and of a paler green hue. The stamens and inner surface of the subtending bract were covered with a white substance which at first glance gave the impression of white fly, but which on examination was found to be the white spore-cluster and basidia of a fungus belonging to the genus Microstroma. A little later when the pollen was being shed the contrast between healthy and diseased catkins was made more conspicuous by the failure of infested anthers to dehisce.

Sections of diseased anthers showed that, while the tissues in direct contact with the mycelium were not killed outright, the pollen grains were mostly degenerate, empty, and often collapsed shells. The mycelium is entirely intercellular, often forming thick mats which wedge the host cells apart and cause the slight distortion of the diseased parts. These mycelial mats become especially prominent at points near the surface where the large basal stroma of the fruit-body is formed in the loose subepidermal parenchyma. From this structure the club-shaped basidia push through the epidermis forming a small but compact hymenium above the surface of the host tissue. The individual threads of the intercellular mycelium and also of the stromata are extremely small and difficult to distinguish as such.

Apparently no toxic substances or injurious enzymes are secreted by the fungus, since the protoplasts and nuclei in the infested tissue retain nearly normal appearance. The changes in cells entirely isolated by the mycelial mats indicate starvation rather than toxemia. The pollen grains present similar evidences of starvation. The vacuole gradually enlarges and the protoplasmic layer becomes thinner until it disappears entirely leaving the empty pollen-cell walls which collapse or retain their original shape according to their degree of maturity.

IDENTITY OF THE PARASITE

Of the four species of Microstroma mentioned in Saccardo's *Sylloge Fungorum*, *M. album* (Desm.) Sacc. occurs on leaves of oak, *M. Cycadis*

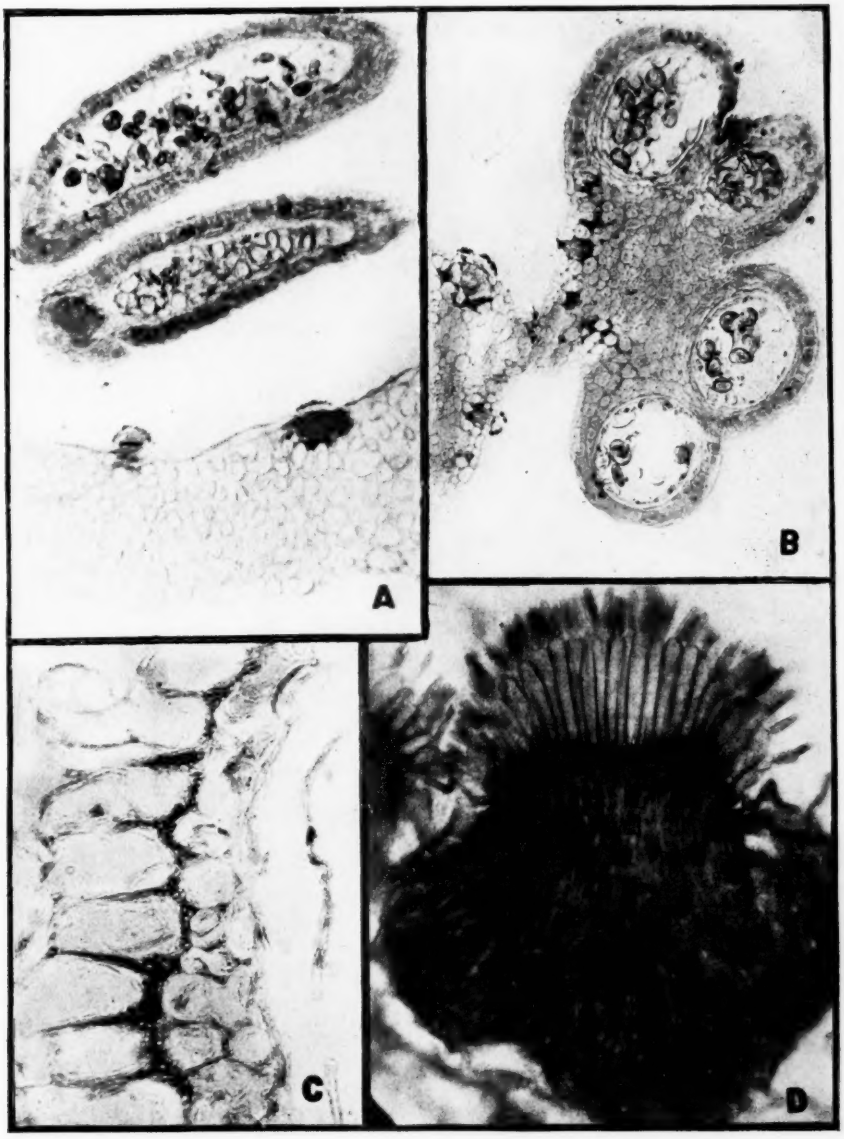

FIG. 1. MICROSTROMA JUGLANDIS VAR. ROBUSTUM ON CARYA ILLINOENSIS

A, longitudinal section of diseased stamen and subtending bract, showing degenerate pollen and also fruiting bodies and mycelial mats of fungus. × 75; *B*, cross-section of diseased stamen and bract. × 70; *D*, fruiting body of fungus from infected bract. × 500; *C*, mycelium between cells of pollen-sac. × 500.

Allesch. on leaves of *Cycas revoluta*, *M. americanum* Pammel & Hume on leaves of *Cnicus americanus*, and *M. Juglandis* (Bering) Sacc. on leaves of Juglans and Carya. Since *M. Juglandis* was abundant early in the spring on leaves of hickories, it was at once suspected that the fungus on pecan catkins was identical with this species. Comparative measurements of the various structures of the fungus from the two hosts showed however some very marked differences. The spores from pecan catkins are cylindrical, 9 to 14 by 5μ, and those from hickory leaves are oval to

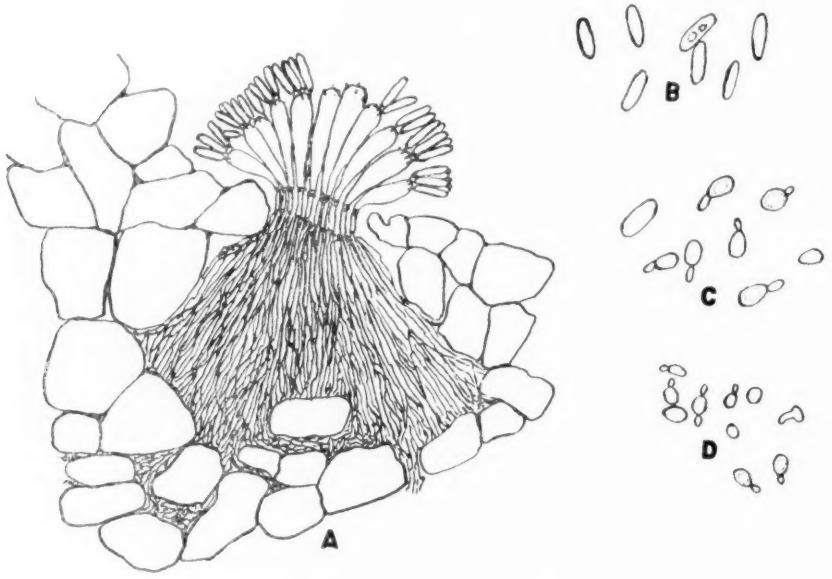

FIG. 2. CAMERA LUCIDA DRAWING OF MICROSTROMA JUGLANDIS VAR. ROBUSTUM

A, fruiting body showing basidia, sterigmata, and spores; *B*, fresh spores; *C*, yeast-like cells from eight-days-old culture on corn meal agar; *D*, cells from old culture on corn meal agar. All × 775.

oblong, 6 to 8 by 4.5μ. The basidia as well as the stromata from which they arise are much larger and the number of basidia from each stroma much greater on the pecan.

Cultures of both forms were obtained and compared on various media. The responses were very similar in each case. On all media so far tried, only a yeast-like growth is formed. The spores swell considerably and within a few hours begin forming new cells by a budding process, soon forming a small, circular white colony. At first short hyphal germ tubes were found occasionally, but they soon disappeared. As the budding process continues the daughter cells become smaller and oval or elliptical

to globose. The fungus is not long-lived in cultures, requiring frequent changes to new media.

Early in May direct and cross inoculations were tried with fresh spores from each host, but they all resulted in failure.

Diligent search for diseased catkins was made over several hickory trees the leaves of which were infested with Microstroma but none were found. Neither was any disease found on the leaves of pecan trees, although in some instances they were almost in contact with diseased hickory leaves.

Notwithstanding the apparent difference in tissues attacked, in size of spores, basidia and so forth, it still seems doubtful that the pecan fungus should be given specific rank. The more robust habit on the catkins may be due to the more abundant supply of food. Therefore for the present, it seems best to consider the fungus on pecan catkins as merely a robust variety of *Microstroma Juglandis* (Bereng.) Sacc. and to present the following diagnosis:

Microstroma Juglandis (Bereng.) Sacc. var. **robustum** n. var.

Host tissue pale, often slightly distorted; mycelium intercellular, forming more or less dense mats between the host cells; fruiting stromata oval to short conical, 60 to 100 by 55 to 150μ, composed of very slender interwoven threads; basidia club shaped, 13 to 30 by 5μ, bearing apically 6 to 8 spores on short sterigmata; spores hyaline, one-celled, cylindrical, rod-shaped, 9 to 14 by 3 to 5μ.

Hab. On stamens and staminate bracts of *Carya illinoensis*.

Microstroma Juglandis (Bereng.) Sacc. var. **robustum** n. var.

Stromatibus fructificantibus subepidermicis, ovatis vel brevo-conicis, 60 to 100 by 55 to 85μ; basidiis caespitosis, clavatis, 13 to 30 by 5μ., sex-v. octoporis; sporidiis hyalinis, cylindricis, 9 to 14 by 3 to 5μ.

ECONOMIC IMPORTANCE OF THE DISEASE

Since pollen is always produced in super-abundance by pecan trees the loss of a comparatively large amount is of little importance. Since however, on some trees fully one-third of the pollen was destroyed one can readily see how the disease may become serious in the near future. At present so little is known as to the life history of species of Microstroma that any suggestion as to control measures is almost valueless.

Observations in the Station orchard during the past spring indicated that few or no commercial varieties are entirely immune; but the attack was much more severe on some varieties than on others. Similar observations were also made in orchards around Albany, Georgia.

GEORGIA AGRICULTURAL EXPERIMENT STATION
EXPERIMENT, GEORGIA

SOME NEW OR LITTLE KNOWN HOSTS FOR WOOD-DESTROYING FUNGI

ARTHUR S. RHOADS

Despite the great extent to which wood-destroying fungi have been collected, but comparatively little attention has been paid to the host species on which they occur. One frequently finds in herbaria good collections the practical value of which is greatly reduced by being deficient in this respect. Within the last few years, however, increasing attention is being paid to the host species with the result that many new hosts have been established and many fungi which formerly were thought to be confined entirely to the wood of deciduous or coniferous trees are now known to occur on both.

In his own collecting work the writer always has been particularly interested in the hosts for wood-destroying fungi and frequently collects for host species alone. In looking over his lists recently a few species were noted, some of which apparently never have been reported. All but two of the collections cited here have been made by the writer himself or in conjunction with others, either in the states of Pennsylvania or New York. The following host species for wood-destroying fungi are believed to be new or at least little known.

Coriolus versicolor[1]

On dead trees, fallen trunks, and stumps of *Tsuga canadensis*[2] (Pa. and N. Y.).

On rustic fence rails of *Juniperus virginiana* (Pa.).

On fallen trunks and stump of *Abies balsamea* (N. Y.). This species was noted as a host by Dr. L. H. Pennington on two occasions in the Adirondack region.

Coriolus nigromarginatus

On a dead trunk of *Tsuga canadensis* associated with *Coriolus abietinus* (N. Y.).

Coriolus prolificans

On dead trunks of *Tsuga canadensis* (Pa. and N. Y.). Numerous sporophores occasionally are found either pure or associated with *Coriolus abietinus*. It pro-

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[1] The nomenclature for fungi used in this paper is that of William A. Murrill. [(Agaricales) Polyporaceae (pars). North Am. Fl. **9**: 1–72. 1907; (Agaricales) Polyporaceae (concl.). North Am. Fl. **9**: 73–131. 1908.]

[2] The nomenclature for trees used in this paper is that of George B. Sudworth. (Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Agr., Div. Forestry Bul. **17**: 144 p. 1898.)

duces a sap-rot in hemlock that is indistinguishable, macroscopically at least, from that caused by *C. abietinus*.

Coriolellus sepium

On rustic fence rails of *Juniperus virginiana* (Pa.).
On stump of *Tsuga canadensis* (N. Y.).

Tyromyces cæsius

On rustic fence rails of *Juniperus virginiana* (Pa.).

Bjerkandera adusta

On rustic fence rails of *Juniperus virginiana* (Pa.).
On stump of *Thuja occidentalis* (Pa.).

Porodisculus pendulis

On branches of fallen trunks of *Juglans cinerea* (N. Y.). This fungus usually is collected on wood of *Castanea dentata* but occurs commonly about Syracuse on butternut wood.

Polyporus Polyporus

On slash of *Tsuga canadensis* (Pa.).

Pycnoporus cinnabarinus

On a fallen sapling of *Tsuga canadensis* (Pa.).
On log of *Picea rubens* in corduroy road (N. Y.).

Hapalopilus gilvus

On a dead sapling of *Tsuga canadensis* (Pa.).

Ischnoderma fuliginosum

On dead trunk of *Pinus strobus* associated with *Coriolus abietinus* (N. Y.).

Elfvingia megaloma

On dead trees, fallen trunks, and stumps of *Tsuga canadensis* (Pa. and N. Y.).
On stump of *Abies balsamea* (N. Y.).

Ganoderma Tsugæ

On or in close contact with stump of *Pinus rigida* (Pa.).
On stump of *Picea excelsa* (Pa.).
On a much decayed stub of *Betula lutea* (N. Y.). A fine large specimen was collected on the latter host at Cranberry Lake, New York, and was fully as typical as those frequently found on hemlock trunks in that region.

Glœophyllum trabeum

On rustic fence rails of *Juniperus virginiana* (Pa.).

Glœophyllum hirsutum

On a soft maple log in a wharf at Oneida Lake, New York. Occasional sporophores were associated with its near relative, *Gloeophyllum trabeum*. The wood was either that of *Acer saccharinum* or *Acer rubrum*, but judging from the dominance of the silver maple in the lowlands of this region, it probably was the former species.

On stump and adjacent log of *Prunus avium* (Pa.). Near State College, Pa., sporophores were found at various times associated with *Gloeophyllum trabeum* on a stump and nearby log from the same tree.

On fallen trunk of *Betula lutea* (N. Y.). A collection of this plant was found in the herbarium of the New York State College of Forestry and, although no host was recorded, a few sporophores had ample bark attached to them to be positively certain that they grow on yellow birch.

Glœoporus conchoides

On an old sporophore of *Inonotus dryophilus* (Pa.). In making a collection of the former plant from a black oak log an old sporophore of *Inonotus dryophilus* was found on the log that also was well covered with sporophores of *Glœoporus conchoides* and seemed to be as good a host for this plant as the wood of the log.

THE NEW YORK STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY
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NOTES ON CRONARTIUM COMPTONIÆ III

PERLEY SPAULDING

In 1908 the writer collected a specimen of *Cronartium Comptoniæ* Arthur on a young tree of *Pinus rigida* at Burlington, Vermont. Since that time all available information concerning this fungus has been accumulated, and all the experimental work possible has been done. Three brief papers[1] have been published giving some of the more important facts which have been learned. It is proposed in the present paper to state very briefly some results secured in more recent investigations.

The pine hosts of *Cronartium Comptoniæ*, which have been previously reported by various writers, are *Pinus rigida* Mill., *P. sylvestris* L., *P. maritima* R. Br., *P. austriaca* Hoess., *P. divaricata* Ait., *P. echinata* Mill., *P. montana* Du Roi, *P. ponderosa* Laws., *P. contorta* Loud., *P. virginiana* Mill., and *P. tæda* L. In the years 1915 and 1916 *Cronartium Comptoniæ* has been received by the writer from various localities on the following new pine hosts: *Pinus densiflora* Sieb. & Zucc. (one locality), *P. jeffreyi* Oreg. Comm. (two localities), *P. laricio* Poir. (one locality), *P. mugho* Poir. (three localities) and *P. resinosa* Aiton (one locality; three other localities are known but no specimens could be secured).

Successful inoculations have been made by the writer and his colleagues named below, for the first time, so far as can be determined from published statements, from several pines to the alternate hosts. Uredinia were produced on plants of *Comptonia asplenifolia* L. with aeciospores from *Pinus tæda* (one test made), *P. austriaca* (2 tests), *P. rigida* (4 tests) *P. mugho* (3 tests), *P. resinosa* (1 test), *P. jeffreyi* (1 test), *P. laricio* (1 test). Uredinia on Comptonia were successfully used to produce uredinia on Comptonia and *Myrica gale*. Uredinia from *Myrica gale* produced uredinia on Comptonia. These are the first successful inoculations with uredinospores to be reported. In the winter of 1914–15 a special effort was made to secure living plants of all the species of Myrica growing in this country. A stock of the following species was obtained largely through the efforts of G. G. Hedgcock and E. P. Meinecke: *Myrica gale* L., *M. californica* Cham., *M. cerifera* L., *M. carolinensis* Mill., *M.*

[1] Spaulding, Perley. Notes on Cronartium Comptoniæ. Phytopath. **3**: 62. F. 1913.
——. Notes on Cronartium Comptoniæ II. Phytopath. **3**: 308-310. D. 1913.
——. Notes on Cronartium Comptoniæ and C. ribicola. Phytopath. **4**: 409. D. 1914.

inodora Bartr., *M. pumila* Michx., as well as *Comptonia asplenifolia*. Mr. G. F. Gravatt and Dr. G. R. Lyman in 1915 made inoculations under the writer's direction. Five different series of inoculations, with aeciospores from as many different species of pine, were made. The results were as follows:

3 plants—*Comptonia asplenifolia*—uredinia produced on all.
7 plants—*Myrica gale*—uredinia produced on all.
9 plants—*Myrica carolinensis*—no infection.
4 plants—*Myrica californica*—no infection.
5 plants—*Myrica inodora*—no infection.
3 plants—*Myrica pumila*—no infection.
4 plants—*Myrica cerifera*—no infection.

A single plant of *M. carolinensis* was inoculated repeatedly in 1916 by the writer without visible results other than yellow spots on the leaves, which are thought to be due to some other cause. Numerous successful inoculations have been made on *Comptonia asplenifolia:* i.e., a total of two in 1912, eleven in 1913, two in 1914, nine in 1915, and fourteen in 1916. A lesser number has been made on *Myrica gale*, which gives much less striking results. The total number of such successful inoculations on *Myrica gale* is: seven in 1915 and four in 1916.

In 1912 the writer began a series of annual observations in an area of several acres near Lake George, New York, quite thickly covered with natural reproduction of *Pinus rigida*, in which *Cronartium Comptoniæ* occurs as a native parasite. The size of the trees within the area ranges from twenty feet in height downward. Very few are as small as two feet in height and there seem to be no very young seedlings now appearing. *Comptonia asplenifolia* grows naturally throughout the area so that conditions are excellent for the spread and development of the disease. These observations have continued until the present time, thus covering a period of five years. An effort has been made to keep numbered labels on all of the diseased trees, but with indifferent success because of curiosity or mischief in people who happened to see them. Several significant facts have been learned however. On pines *Cronartium Comptoniæ* fruits for a period of seven or eight weeks, the time of maximum fruiting being about June first—considerably earlier than the writer at first supposed. The number of diseased trees killed annually by the fungus has been surprisingly uniform, ranging from eight to eleven. In 1916 the observations were made earlier than usual and a greater total number of diseased trees were unexpectedly found. There is evidence that a small number of trees are annually infected for the first time and it is hoped to learn this number in the future. It is well established that a tree which once

bears fruit of the fungus almost always bears an annual crop of such fruits until the tree dies. In some cases a dying tree fails to produce them, but on the other hand, recently killed trees are often found with aecia on them. While the annual loss is not great, it is a serious loss when continued indefinitely. Moreover we have excellent reasons for believing that *Pinus rigida*, to which the preceding statements apply, is much less susceptible to the disease than are *P. ponderosa* and *P. contorta*. The loss in some instances, with the latter two species, has been total.[2]

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
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[2]Kauffman, C. H. and Mains, E. B. An epidemic of Cronartium Comptoniæ at the Roscommon state nurseries. Mich. Acad. Sci., Ann. Rept. **17**: 188-189. 1915

FURTHER NOTE ON A PARASITIC SACCHAROMYCETE OF THE TOMATO

ALBERT SCHNEIDER

Since the appearance of the recent article on a parasitic Saccharomycete of tomato[1] it has been determined that the fungus described unquestionably belongs to the genus Nematospora of Peglion.[2] In its morphological characteristics it is closely similar to *Nematospora Coryli* Pegl., which attacks the fruit of the hazel bush (*Corylus avellana*). Peglion, however, makes no reference to the gametic origin of the ascus nor does he note the two cells of the ascospore. He also fails to recognize the arthrospores and includes them under "Anomale vegetative Formen." These and other morphological as well as biological differences make it clear that the *Nematospora Coryli* of Peglion and the fungus under consideration are two distinct species. Both are true parasites and appear to occur in warmer countries (southern Italy, southern California and Cuba) and perhaps also in semitropical and tropical countries.

The Nematospora of the tomato (*Lycopersicum esculentum*) is apparently a new species and the following name is therefore proposed:

Nematospora Lycopersici n. sp.

Asci of gametic origin soon becoming free from associated cells, cylindrical with rounded ends, 60 to 70μ in length; ascospores in two groups of four spores each, two-celled, slender, with pointed ends, slightly ridged at transverse septum, 50 by 4.5μ; ascospores liberated by dissolution of ascus wall and held together somewhat in groups of 4 by motionless flagellae; flagellae 50 to 100μ in length; arthrospores, of non-gametic origin, spherical to ampulliform, 25μ in diameter. Two other cell forms also found: (1) much elongated, filamentous cells; (2) elliptical and ovoid cells, gametic in function, new cells formed in bipolar direction by apical budding and also by apico-lateral budding at cell unions. The elliptical and ovoid cells alone are gametic in function.

Habitat. Parasitic on nearly ripe and ripe fruit of *Lycopersicum esculentum*, southern California, Cuba and Mexico.

[1] Schneider, Albert. A parasitic Saccharomycete of the tomato. Phytopathology **6**: 395-399. 1916.

[2] Peglion, Vittorio. Ueber die Nematospora Coryli Pegl. Centralbl. f. Bakt. Abt. 2, **8**: 754-761. 1901.

Nematospora Lycopersici sp. nov.

Ascis cylindratis, terminato orbiculato; 60–70μ in longitudine; sporidiis 8; dispositis struibus duo, sporidiis 4. Ascus mox ex cellis prehensis liberatus est. Tunicae ascorum in maturitate solventur et sporidiis liberantur. Plurimi asci origine gametata sunt.

Sporis ascorum bi-cellulatis tenuibus, fusiformibus, flagello uno. Sporidiis 50 x 4.5μ, flagello 50–100μ.

Arthrosporis non-gametatis, plerumque sphaeroidis, 25μ.

Cellulis vegetativis, ellipticis, ovatis ad filaris nonramosis, multiplicantibus gemmatando apiculo-laterali apiculatoque. Cellulis ellipticis et ovatis solis sunt gametatis.

Hab. In fructo Lycopersici esculenti, terris calidis et tropicis.

Acknowledgments are hereby made to Dr. Roland Thaxter and Prof. H. W. Anderson for calling the writer's attention to the Nematospora of Peglion.

UNIVERSITY OF CALIFORNIA
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PHYTOPATHOLOGICAL NOTES

Albany conference on white pine blister rust. A joint meeting of the North American Committee for the Control of the Pine Blister Rust and the cooperators of the United States Department of Agriculture was held at Albany, New York, November 20 and 21. The meeting was attended by a representative body of men from the states of New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Virginia, Indiana, Wisconsin and Minnesota, and from the Dominion of Canada and the United States Department of Agriculture. The state foresters, pathologists, and nursery inspectors most interested in the fight for the control of the disease were present.

A brief report from each state and from Canada gave the latest news concerning disease survey and eradication work. The reports show the general epiphytotic of the blister rust in New England and east of the Hudson River, with comparatively few centers of infection in New York, Pennsylvania and New Jersey, one infection center in Ohio, two in Wisconsin, and four in Minnesota. A hasty survey made of the western half of the country failed to show any blister rust of white pine present.

It developed that the matter of control of the blister rust in the New England states resolved itself into the practicability of the eradication of currant and gooseberry bushes on a large scale. The control of the blister rust in the Lake States was shown to be on a somewhat different basis, for in that region the spots of infection known are very few. Here the total eradication of all white pines and Ribes near the infection center is being carried out.

The Committee passed resolutions favoring adequate legislation which would permit states to carry out the eradication or control work necessary, following largely the Sanders model horticultural inspection bill. They also favored adequate appropriations by the states to carry on eradication work and by the Federal Government to carry on the survey and experimental work. The Committee favored a Federal quarantine prohibiting shipment of five-needled pines and all species of Ribes from the eastern half of the country to any part of the country west of Minnesota, Iowa, Missouri, Arkansas and Louisiana. A state quarantine was also recommended prohibiting shipment of five-needled pines and Ribes from infected states to others not infected.

A national law was urged prohibiting the importation of all plants

from any other continent into the United States except through the United States Department of Agriculture solely for scientific and experimental purposes.

ROY G. PIERCE

Corn disease caused by Phyllachora graminis. During the summer of 1915, an apparently undescribed disease of corn was observed by F. L. Stevens in Porto Rico. Leaves were collected from the diseased fields in numerous localities in Porto Rico, and a study of the disease based entirely on this herbarium material has been made at the University of Illinois.

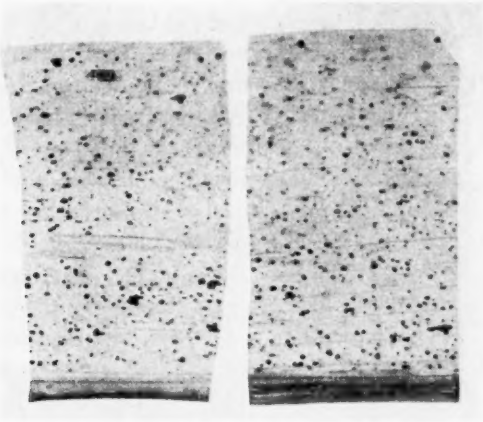

FIG. 1. PHYLLACHORA GRAMINIS ON CORN

Portion of a leaf shows stromata on upper and lower surfaces

The disease manifests itself as well-defined, subcarbonaceous spots, either small and numerous or comparatively large and sparsely distributed, and in either case surrounded by a narrow, yellowish-brown halo. The infection is local, confined to the leaf and the leaf sheaths, and is visible on both upper and lower surfaces.

The spots are due to the formation of stromata in the infected tissue. Embedded in the stromata are perithecia consisting of depressed cavities surrounded by walls made up of dark-brown mycelium and bearing at the top a comparatively small ostiole.

The mycelium in newly invaded tissue is slender and hyaline. It later becomes dark brown, filling the leaf tissue of the infected area with a network of hyphae.

The asci are numerous. They are cylindrical and in each ascus are produced eight unicellular, hyaline, thin-walled spores.

The fungus causing the disease has been identified as *Phyllachora graminis*.

A report including a detailed description of the disease and fungus, together with notes concerning the generic and specific relationship, will be read before the Illinois Academy of Science at its next meeting.

NORA E. DALBEY

Tylenchus tritici on wheat. In August, 1915, specimens of diseased wheat plants, which had just been received from Dr. J. H. Reisner, of the University of Nanking, Nanking, China, were kindly turned over to the writer by Dr. H. B. Humphrey, of the Office of Cereal Investigations, Bureau of Plant Industry. In transmitting this material by letter Dr. Reisner said, "The disease has become more widespread every year for the last three or four years and is causing great money losses."

A microscopic examination of the wheat heads showed that practically all of their glumes contained, in place of normal kernels, dark galls filled with an almost innumerable number of motionless but living larvae of the nematode, *Tylenchus tritici* Bauer, which has been known as a serious pest in Europe since 1745. The parasite has been found in Sweden, Holland, Germany, Austria-Hungary, Switzerland, Italy, England, and Australia, but so far as known has never been reported from China before. Johnson[1] recorded in 1909 the occurrence of what undoubtedly is the same species on wheat from a few widely separated sections in the United States, but as no reports of its appearance before or since that date have been found, it is quite unlikely that the eelworm has become well established in the wheat areas of this country. Whether the closely related species of Tylenchus found by Bessey[2], the writer, and others on several different grasses in various parts of the United States is identical with the form on wheat has not been determined. Some European investigators, however, regard *Tylenchus tritici* as a highly specialized parasite of the wheat.

The infected heads of wheat are usually shorter and thicker than normal heads and contain glumes which spread out almost at right angles to the fruit stem. In place of normal seed, dark, hard galls, incapable of germination and full of larvae, are to be found. Because of these effects on the host the disease has merited such descriptive names as ear-cockles, purples, false ergot, etc.

[1] Johnson, Edw. C. Notes on a nematode in wheat. Science n. s. **30**: 576. 1909.
[2] Bessey, Ernest A. A nematode disease of grasses. Science n. s. **21**: 391. 1905.

Active larvae enter the young, tender tissues of the wheat flower, extract food therefrom, mature, and lay eggs, which in turn give rise to another generation of larvae. After reaching a certain stage of development some of the subsequent generations of larvae become coiled and dried out in the matured seed coats of the host and are capable of remaining in this inactive condition for long periods. Under favorable conditions of moisture and temperature the eelworms may escape from the seed, attack the leaf and stem parts of wheat seedlings, causing them to become wrinkled, distorted, or swollen, and finally enter the embryonic seeds.

It has seemed desirable to bring the above data to general attention, in the hope that active measures will be taken both to prevent the introduction of this parasite along with wheat importations from infected countries and to stamp out the pest wherever it is found in this country.

L. P. BYARS

The Botanical Society of Washington. The following officers have been elected for the ensuing year:

President, Mr. T. H. Kearney; Vice-President, Mr. Edgar L. Brown; Recording Secretary, Mr. Charles E. Chambliss; Corresponding Secretary, Dr. H. L. Shantz; Treasurer, Mr. F. D. Farrell.

Mr. A. S. Hitchcock was nominated by the Society for the position of Vice-President of the Washington Academy of Sciences.

Personals. Mr. Chas. S. Reddy, of the University of Wisconsin, has been appointed as assistant plant pathologist, and Mr. A. M. Christensen, of the North Dakota Experiment Station, as an agent, in Cereal Disease Investigations, Bureau of Plant Industry, with headquarters at Fargo, North Dakota, where they are engaged in the investigation of cereal diseases in cooperation with the North Dakota Station.

Mr. F. A. McLaughlin, instructor in botany at the Massachusetts Agricultural College, has been granted a year's leave of absence for graduate study at the University of Chicago.

Mr. W. L. Doran, for the last two years graduate assistant in botany at the Massachusetts Agricultural College, has been appointed instructor in botany and assistant botanist at the New Hampshire Agricultural College and Experiment Station.

ABSTRACTS OF PAPERS PRESENTED AT THE EIGHTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, NEW YORK CITY, DECEMBER 26-30, 1916

Evidence of the over wintering of Cronartium ribicola. PERLEY SPAULDING

Numerous instances have been noted where large lots of black currants were very heavily infected with *Cronartium ribicola* one summer and not the next. In the Geneva New York case the disease was present upon pines and these in the writer's opinion started the disease each spring. Cooperative experiments with Stewart, in which 500 heavily infected black currants were used, resulted in no disease. Furthermore, the writer has had during the past seven years in the greenhouses at Washington, hundreds of Ribes plants of more than thirty species, which have been used in inoculation experiments. In no case has the disease ever appeared upon these the next season until artificial inoculations had been made. Uniform success has been obtained personally in locating the diseased pines from the areas occupied by the first generation of uredospores in the field. Field observations seem to indicate that the disease has been shipped into new localities on infected Ribes. Infections of petioles are not as rare as at first supposed. No evidence of bud infection by way of the petiole has yet been secured. Direct examination of buds on infected plants has also failed to show the presence of the disease.

The control of white pine blister rust in small areas. W. H. RANKIN

The control of white pine blister rust has been attempted in eighty-five forest plantings made with imported stock in New York State. Diseased or suspicious trees and all currants and gooseberries within five hundred feet of the plantings were removed. Thirty-six plantings have shown diseased trees since 1909; twenty since 1911; seventeen since 1912; fifteen since 1913; nine since 1914 and four since 1915. The *Ribes* sp. within one-half mile of all the plantings were inspected in the autumn of 1916. Diseased *Ribes* sp. were found around two, only. These were two of the four which had shown diseased trees in the spring. In both cases cultivated varieties of *Ribes* still existed within five hundred feet. It seems, therefore, that the removal of diseased trees and all currants and gooseberries within five hundred feet of the plantings has prevented the establishment of *Cronartium ribicola* in these areas.

Citrus canker investigations at the Florida Tropical Laboratory. R. A. JEHLE

Some cultural characteristics of the canker organism, *Pseudomonas Citri* Hasse (Migula's genus) or *Bacterium Citri* (Cohn's genus Bacterium as emended by Smith) are as follows: Growth on standard agar abundant, spreading, raised, smooth, glistening, transluscent, pale yellow, viscid, with characteristic odor in about five days. Vitality ten to thirty days. Growth on potato agar more abundant and spreading with lighter color. Growth on potato slices more viscid and brighter yellow with distinct white margin on potato adjacent to culture. White margin becomes very prominent in forty-eight hours and does not stain with iodine. On grapefruit leaf and stem decoction agar slants growth penetrates the agar and is

less raised. On oat agar slants growth is much more spreading and the color is much lighter.

Positive results have been obtained from inoculations on grapefruit, ponderosa lemon, key lime, *Citrus trifoliata*, sour orange, tangelo, sweet orange, tangerine, king orange, mandarin-lime, and kumquat. Disease also occurs on navel orange, mandarin, satsuma, common lemon, rough lemon, and *Aegle glutinosa*.

Studies upon the anthracnose of the onion. J. C. WALKER

A morphological study of the causal organism *Colletotrichum circinans* (Berk.) Vogl. shows the fruiting body to be an acervulus and not a pycnidium as first described by Berkeley, confirming the findings of Voglino who transferred the fungus from the genus Vermicularia to Colletotrichum. Further study has shown it to conform closely to the description of *Colletotrichum fructum* (S. & H.) Sacc. (*Volutella fructi* S. & H.), reported by Stevens and Hall as causing a fruit rot of apple. Inoculation of the fungus from onion into apple fruits resulted in a rot very similar to Volutella rot. Further study is necessary before the two fungi can be considered as identical.

Inoculation of onion bulbs in soil held at different temperatures shows best infection to take place between 24° and 29°C. This may account in part for the rather sparing appearance of the disease until shortly before harvest. The fungus over winters in the soil and consequently the disease is most severe on old onion fields.

Spraying the bulbs before harvest or in the crates after harvest has not proved beneficial. The fact that yellow and red varieties of onion are highly resistant offers some encouragement for the development of a resistant white strain. Work in this direction is to be continued.

Pink root, a new root disease of onions in Texas. J. J. TAUBENHAUS and A. D. JOHNSON

A new disease known as pink root is causing serious losses to onion growers of Webb County, Texas. The trouble seems to prevail only where onions are grown for two years or longer on the same land. The same is also true for the seed bed where the same old soil is used for several years in succession. The disease starts with the young sets in the seed bed and from there is carried to the field.

The roots of the affected sets in the seed bed or the plants in the field turn pink in color then strivel and die. As fast as new roots are formed they become infected, turn pink and dry. The effect of pink root is to prevent the normal development of the bulbs in the field and to produce dwarfed undersized bulbs which are absolutely worthless as far as the market is concerned. The cause of the disease is still problematic. Attention is called to it at this time because of its great economic importance to Texas onion growers. Extensive investigations are now under way to determine the cause and possible remedies for this disease.

Two new camphor diseases in Texas. J. J. TAUBENHAUS

Two new or little known diseases seem to threaten the existance of camphor trees in Texas:

1. *Anthracnose.* The fungus attacks and kills the leaves and branches. Affected trees have a defoliated appearance at the top. The cause of the trouble is apparently a new species of Glœosporium tentatively named *Glœosporium camphoræ*. The organism is readily grown in pure culture and the disease reproduced at will.

2. *Limb canker.* This disease is characterized by a dying of the larger limbs to about four to six feet from the top. The limbs turn dark and soon shed their leaves. Affected trees have a ragged and burned appearance. A fungus of the genus Diplodia

is always associated with this disease. Investigations are now under way to determine whether this Diplodia is the same or similar to *D. Camphoræ* F. Tassi, occurring in Italy, and whether also it is the direct cause of the disease. A full description of the two organisms will appear at a later date.

Common and scientific names of plant diseases. M. B. WAITE

Common names of plant diseases are used by a larger number of people than scientific names. Pathologists should encourage the movement to make common names definite and national. By being made definite they can attain their proper status in discussions, literature, dictionaries, quarantine regulations, laws, and legal proceedings. By agreement among pathologists they may even become more fixed than scientific names.

There may be four distinct names connected with every parasitic disease; the common name of the disease, the scientific name of the disease, the common name of the parasite, the scientific name of the parasite. For example: lemon scab, Verrucosis, lemon scab fungus, *Cladosporium Citri*. In case of all common diseases the aim should be to provide these four names. Confusion has resulted in the failure to recognize these four kinds of names, particularly in the use of the scientific name of the disease and the scientific name of the fungus as the common name of the disease. Scientific names may become common names through use but these cases should be clearly recognized as such and avoided if possible and vacancies in names also recognized.

Nonparasitic diseases may have two names, common and scientific, and the same principles apply.

Economic hosts of Sclerotinia libertiana in tidewater Virginia. J. A. MCCLINTOCK

The warm, humid climate of tidewater Virginia is especially favorable to the development of *Sclerotinia libertiana*. This fungus, long known as a serious parasite on lettuce, has been observed to destroy over fifty per cent of the autumn lettuce crop on farms where no rotation is used. In the fall of 1915 a serious disease of snap beans due to this organism was found. During the winter of 1915–1916 *Sclerotinia libertiana* was found to be the cause of a fruit rot of tomato in the greenhouse. In winter-grown parsley, under sashes, this fungus in one case caused drop of ten per cent of the crop in the infected frames. *Sclerotinia libertiana* caused the damping off of a large proportion of the seedling plants in several cold frames of cauliflower being raised for a spring crop of 1916. In the summer of 1916 this fungus caused a stem blight of bearing egg plants, on several farms. In each case the writer was able to isolate the causal organism and to reproduce the disease in the respective hosts, and in other hosts by cross inoculation.

Lima bean mosaic. J. A. MCCLINTOCK

During the summer of 1916 while conducting experiments with nine varieties of pole, and seven varieties of bush lima beans, the writer observed a serious mosaic. It was observed first on the Sieva pole lima or butter-bean and later on Improved Henderson's Bush and Prolific bush, lima beans of the Sieva type.

Over twenty-five per cent of the several hundred plants of each of the abovementioned varieties were stunted and bore the dwarfed, mottled, wavy leaves, characteristic of this mosaic. None of the varieties of larger limas, which made up the remainder of the planting, showed signs of this mosaic, though they were grown under the same conditions and in many cases intertwined with the mosaic diseased plants

of the Sieva type. Lima beans had not been grown on this land previously and no beans of this type were growing nearby, therefore, it was concluded that this lima bean mosaic was carried by the seed. This disease is serious because the yield on the infected plants is greatly decreased and the pods are smaller and malformed.

Bean mosaic. V. B. STEWART and DONALD REDDICK

Hundreds of acres of pea beans (*Phaseolus vulgaris*) in New York showed the mosaic disease in 1916 and in some fields practically every plant was affected. Affected plants rarely set pods. The disease is not confined to pea beans. Numerous other varieties of dry and snap beans showed the disease but not so commonly as pea beans.

The mosaic-diseased leaves on affected bean plants show irregular crinkled areas, somewhat deeper green in color than the surrounding yellowish green tissue. The disease is transmitted through the seed. Bean seed from mosaic-diseased plants developed diseased seedlings. Healthy seedlings rubbed with crushed mosaic-diseased leaves showed infection four weeks later. The first signs of the disease appeared in leaves which developed about blossoming time. Leaves which had developed previously remained healthy. High temperature and humidity at time of inoculation slightly favor infection.

Two transmissible mosaic diseases of cucumbers. IVAN C. JAGGER

In Phytopathology for April, 1916, there is a group of articles, dealing with a mosaic disease of cucumbers, commonly known as white pickle, which causes a motling of both leaves and fruits. In the vicinity of Rochester, New York, there occurs a second and distinct mosaic disease, which exhibits a mottling of the leaves, but shows no effect on the fruits. The latter disease has been repeatedly transmitted to healthy plants by rubbing with crushed diseased leaves, and has been transmitted to muskmelons and to summer-crookneck squashes. This may be the disease observed by Selby in Ohio and by Stone in Massachusetts.

Bean diseases in New York State in 1916. W. H. BURKHOLDER

An investigation of the diseases of the field bean in western New York begun in 1915 was continued during the summer of 1916. The most serious disease, a dry root rot, caused by a species of Fusarium, was reported last year. Morphologically the pathogene is nearly identical with *Fusarium Martii* Ap. and Wr., although infection was not obtained by inoculation with the latter fungus. The organism winters over in manure where bean straw has been used as feed, and thus may be spread from field to field. There is also evidence that the fungus may live for many years in the soil. The disease was found in practically all of the one hundred and fifty fields visited in western New York. Apparently all varieties of beans are equally susceptible to the disease although certain undesirable types of the white marrow are very resistant. A few individuals of these have been selected for breeding stock.

The blight, caused by *Bacterium Phaseoli*, and the mosaic along with dry weather also aided in reducing the bean crop of 1916. There is some indication that *Bacterium Phaseoli* causes a stem girdling. Anthracnose was destructive in 1915, but caused little damage in 1916.

Do the bacteria of angular leaf spot of cucumber overwinter on the seed? EUBANKS CARSNER

This question was first suggested by the writer's observation in June, 1915, of the occurrence of angular leaf spot in a field on recently cleared land surrounded

by woods near Portsmouth, Virginia. This field was removed at least three or four miles from any other cucumber patch.

In 1916 near Madison, Wisconsin, six separate experimental fields were planted with seed from the same source on land which had not been planted to cucumbers for at least three years. The disease appeared on seedlings in all of these fields and in three of them it was noted on the cotyledons. In three commercial fields in the same vicinity, planted with seed from other sources, the disease did not appear at all in one case and not until late in the season in the other two.

The fact that angular leaf spot appeared on seedlings only in the six fields planted with seed from the one source and not in the other fields in the vicinity furnishes the basis for the working hypothesis that the causal organism is seed-borne, and is opposed to the theory of local overwintering of the organism by means of insects or plant debris.

Infected cucumber fruits in considerable numbers have been seen by the writer in seed fields. The method of securing and cleaning the seed affords ample opportunity for the organisms to reach the seed, and the process includes no operation that would be likely to kill all of the bacteria.

Preliminary notes on a new leaf spot of cucumbers. GEO. A. OSNER

During the seasons of 1915 and 1916, the writer's attention was called to a peculiar leaf spot on cucumbers that was causing more or less damage in a number of fields. The spots varied from two tenths to fifteen millimeters in diameter, the majority of the smaller spots ranging from one to two millimeters and being limited in most cases by the veins of the leaf. The larger spots were white or tinged with brown and with reddish brown areas along the veins of the leaf which gave the spots a characteristic mottled appearance.

The disease was found to be due to a fungus belonging to the Dematiaceæ-Dictyosporæ group of the Hyphomycetes. Its exact generic position has not been determined as yet. The organism was secured in pure culture on string bean agar and successful inoculations have been made on young cucumber plants in the greenhouse, the checks remaining healthy in all cases.

Virulence of different strains of Cladosporium cucumerinum. W. W. GILBERT

A considerable number of strains of the cucumber scab fungus, *Cladosporium cucumerinum*, have been isolated from cucumber fruits from different localities and grown in culture, and many series of inoculation experiments have been made on seedlings and young and old plants. It has been found that these strains vary widely in their ability to infect cucumber plants. Some have failed to produce any infection after many trials, while others are uniformly virulent. One strain in particular has given very striking infection practically every time when favorable conditions were maintained. The virulent strains attack cotyledons and stems of young cucumber seedlings in moist chambers and kill them in two to four days. They also attack and kill very rapidly the younger leaves, stems and growing tips of larger plants under favorable moisture conditions. Under identical conditions the nonvirulent strains failed to produce infection. Similar results were secured when young cucumber fruits were inoculated in moist chambers with different strains of Cladosporium.

Dissemination of the organism of cucumber anthracnose. M. W. GARDNER

In a fairly large acreage of cucumbers and other cucurbits under observation in 1916, the appearance of original centers of anthracnose in only the plots or fields

planted with seed from certain sources pointed suspiciously toward disease introduction with the seed. Subsequent inspection of seed farms revealed the presence of anthracnose on seed fruits and that the processes involved in seed extraction may furnish effective means of seed contamination.

Extensive spread from original centers of infection in the cucumber fields under observation followed periods of heavy rainfall. The principal direction of spread was that of the surface drainage. Plate isolations of the fungus were made from soil near diseased plants. Rows of healthy seedlings exposed to drainage water in diseased fields during heavy rains the first week of September became abundantly infected and many seedlings were killed outright.

Glass tumblers were sunk in the ground at various points in two fields to intercept surface drainage during rains. A successful plate isolation of the fungus was made from water thus collected. Samples collected in one field after rains on September 5 and in the other field after rains on September 12, when sprayed or sprinkled on healthy potted cucumber plants, produced numerous anthracnose lesions.

A bacterial stem and leaf disease of lettuce. NELLIE A. BROWN

A serious stem and leaf disease of lettuce appeared in Beaufort County, South Carolina, 1916. The disease occurred chiefly on two plantations, one of seventeen, the other of nine acres; a conservative estimate of loss on the former was sixty per cent; on the latter ninety per cent. Other plantations within a radius of twenty miles suffered one to ten per cent loss.

The affected plants were wilted, the outer leaves blotched and darkened. Rotting was often rapid. A cross-section of stem at an early stage of disease showed a blue-green color; later stage, brown. Both pith and vascular regions were involved. Later the stem usually became dry and brittle. Moderately diseased plants are darkened in patches in stem, and vascular region. Bacteria filled the cells of the blue-green and brown areas. No fungi were found.

A bacterial organism was isolated which when inoculated into lettuce produced the blue-green color throughout the vascular system and pith, which later became brown. Disease appeared on leaves also. Eight months after isolation this organism, which is yellow on various media and is doubtfully motile, is still infectious. In its morphological and cultural characters it does not correspond with any organism recorded as pathogenic to lettuce.

Black spot of pepper. L. E. MELCHERS and E. E. DALE

In 1915 a striking pathological condition of fruits of peppers was noticed; the disease ranging as high as 45 per cent. A species of Alternaria has been consistently associated with diseased areas. These are slightly sunken, dark colored and not confined to any particular location. Inoculations show that the organism is only a weak pathogene when inoculated into normal tissue. When the pericarp is mechanically (slightly) injured, the fungus becomes established and diseased areas enlarge. There are apparently two ways or combinations of factors in which natural injuries may occur to peppers in the field; (1) injured areas from sun-scald, (2) frost injuries. Artificially injuring the pericarp by means of a burning-glass and applying the fungus superficially, produces a condition which is the counterpart of the symptoms occurring in the field. Varietal resistance is shown by the data of 1916. Sweet peppers are more susceptible than the hot varieties. Among 15 varieties grown, the percentage of disease ran from 0.02 to 2.7 among hot peppers and from 0.4 to 23.07 among the sweet ones, with an average of 13.6 among the latter when sprayed and 11.7 in the unsprayed. Bordeaux sprays do not control the malady. Affected fruit is unsalable.

A sclerotium disease of peppers. WILLIAM H. MARTIN

The disease is characterized by the presence of numerous, minute, black sclerotia throughout the fruit as well as on the seeds. With the exception of a blackening of the epidermis, the disease may pervade the entire interior before any external symptoms are noticed.

The fungus was isolated and grown in pure culture. The pathogenicity of the fungus has been fully established by numerous successful inoculations on both green and ripe fruit, as well as on the plant itself, and by the subsequent re-isolation in pure culture. Reinoculations with this second isolation again produced the typical rot.

The identity of the pathogene has not been satisfactorily determined but there is evidence for the belief that it is *Sclerotium bataticola* Taubenhaus.

Successful cross inoculations have been made on pepper and sweet potato as well as on cucumber, tomato, apple and egg plant.

Dissemination of Bacterium Malvacearum. R. C. FAULWETTER

Through investigations of the means by which *Bacterium Malvacearum* may be disseminated, it has been concluded that wind during rainfall is the most important agent. Neither insects nor seed infection can account for the prevalance of the angular leaf spot caused by it in all varieties of cotton. An inoculation experiment consisting of one row of plants in a field free of the disease was followed within a month by infection of the plants to the east as far as the fourteenth row, and in the next month by the spread of the disease to the west. A second experiment arranged and operating during the second month also showed spread to the west. Practically no disease occurred east or west of uninfected plants in the original rows.

It was demonstrated experimentally that the leaf-surface film during heavy dews contained viable bacteria. It is to be expected these organisms will be present during rains. Westerly winds prevailed during the rains at the time the disease spread to the east, and during the next month the wind direction had changed, blowing from the south-east. Considering the slight disease opposite the uninoculated plants, and the simultaneous change of wind direction and the spread of the disease, it is held that wind during rainfall is the most active agent in the dissemination of the causal organism.

Bacterial diseases of celery. W. S. KROUT

These diseases occur in a region with a deep muck soil and a very humid climate.

Crown rot. This disease is prevalent in the greenhouses and fields. The symptoms are a yellowing of the foliage and a rotting of the crown starting through side roots. Plants are destroyed in from three to four weeks after infection. The causal organisms appear to be a Bacterium and a Fusarium working simultaneously. Steam sterilization and the following chemicals have been applied in varying amounts to the soil for the control of the disease: formalin, calcium chloride, copper sulphate, ferrous sulphate, sulphur, sodium chloride and potash.

Crown rot wilt. This disease is intermittent in its occurrence. It is characterized by a sudden wilting of the entire foliage, an oval hollow cavity in the crown and a badly diseased tap root which serves as a channel of infection.

Bacterial heart wilt. The bacteria attack only the innermost, tender leaves causing a wet, carbonaceous rot. The organism has been isolated and its pathogenicity proved.

A bacterial blight of soy bean. A. G. JOHNSON and FLORENCE M. COERPER

For a number of years this disease has been under investigation at Madison, Wisconsin. A malady apparently the same has also been reported from other parts of the United States. At Madison the disease has been common during the past three years, especially on the leaves.

These leaf lesions are small, rather angular spots, in late stages, dark in color, brown to purplish black. In the earlier stages they are translucent and water soaked in appearance and yellowish to light brown in color. The lesions may be irregularly scattered or variously grouped and they not uncommonly coalesce. Rather inconspicuous glistening films of exudate are frequently noticeable on the lower surfaces of the lesions.

Repeated isolation cultures have yielded a characteristic, white bacterial organism which has proved pathogenic on soy bean, producing characteristic lesions as described above. The same organism has been reisolated from such lesions and its pathogenicity in turn proved. This organism is a rod with rounded ends, motile by a single polar flagellum, hence referable to the genus Pseudomonas of Migula or the genus Bacterium of Ehrenberg as interpreted by Erwin F. Smith.

Studies on the physiological characteristics of the organism and its pathogenicity on other leguminous hosts are in progress.

Host limitations of Septoria Lycopersici. J. B. S. NORTON

Inoculations of seedlings of a number of Solanaceae and eighty varieties of tomato in humid enclosures, with Septoria from tomato resulted in infections on several species of Solanum, eggplant, *Datura tatula*, and especially on potato, currant tomato and *Solanum carolinense*. Spots developed better and spores larger on potato and horse-nettle than on tomato, while the Datura spots were slow-growing, light colored and small-spored. With larger plants outdoors, infections appeared rarely except on Lycopersicum; but undoubted infections resulted on horse-nettle and potato and occasional pycnidia developed with spores smaller than on tomato. The tomato varieties in the seedling stage, showed decided differences in susceptibility to the Septoria, both in number of infections and time of development. Many dwarf varieties showed marked susceptibility.

Wintering of Septoria petroselina var. Apii. W. S. KROUT

Heretofore, the seed has been considered the primary source for dissemination and wintering of this organism. The following observations and results of tests indicate this is not the case: (a) Pycnidia with spores are found on the pedicles and have been reported on seed. (b) All spores taken from the dried pedicles failed to germinate. (c) Spores from green celery tissues subjected to dessication for eight months under laboratory conditions failed to germinate. (d) Young seedlings in the seed-bed were never infected unless planted on soil that had previously grown celery infected with this organism. (e) This organism forms sclerotial-like intercellular bodies in the petioles. (f) Celery grown in new localities gradually becomes infected. (g) Seed from the same bag, but divided and sown upon two different farms produced the diseased seedlings in one case and healthy seedlings in the other.

These studies indicate that the disease is not carried in the seed but in manures containing diseased, decomposed plants, and probably by other methods.

Laboratory work has shown that heating celery seed to 50°C. for one-half hour will eliminate all chances (if there be any) of the disease being disseminated through the seed and pedicles.

Incomplete studies on *Cercospora Apii* Fr., indicate similar conditions.

A nematode disease of the dasheen and its control by hot water treatment. L. P. BYARS

During the summer of 1914, a new disease of an economic aroid, the dasheen, *Colocasia esculenta* (L.) Schott, was found at one point in Florida causing serious damage. The malady is caused by the widely distributed nematode or eel worm, *Heterodera radicicola* (Greef) Müller, which causes root-knot of many wild and cultivated plants, but which has not heretofore been authentically reported on the dasheen. In some places it has caused almost a complete failure of the dasheen crop and is regarded as the most serious pathological factor in the successful production of this plant.

The disease has been found on dasheens in most of the South Atlantic States where economic aroids are grown and in a shipment of cormels imported from Egypt for propagating purposes.

On dasheen roots the nematode produces macroscopically conspicuous swellings which hinder normal absorption. On the surface of the tuberous growth it causes protuberances and definite raised areas resembling open sores, through which secondary field and storage parasites may readily enter. The eelworm does not live on the aerial parts of the dasheen, but, in case of severe infection, it causes these portions to be greatly reduced in size, and gives to the plant as a whole a decidedly sickly appearance.

The disease has been successfully controlled by planting on uninfected land selected cormels from disease-free areas, or diseased cormels which have been treated with water at 50°C. for forty minutes.

Noteworthy Porto Rican plant diseases. F. L. STEVENS

To be printed in full in the April issue of PHYTOPATHOLOGY.

Sulfuring Concord grapes to prevent powdery mildew. F. E. GLADWIN and DONALD REDDICK

Continuing work reported in Internat. Cong. Vit. Off. Rept. **1915**: 117–125, 1916, plats of Concord grape vines were dusted three times, July 18, August 2 and August 16, with sulfur-lime mixtures containing respectively twenty-five, fifty and seventy-five percent sulfur flour, ninety-five per cent or more of which passes 200-mesh sieve. The mixtures were applied at the rate of forty pounds per acre. A single application of Bordeaux mixture was made on one plat on August 11. Treated plats alternated with check plats and all plats were separated by one buffer row.

Powdery mildew, caused by *Uncinula necator*, was abundant. At harvest time one untreated plat showed four per cent of the clusters free from mildew and another only 0.007 per cent free. The bordeaux-sprayed vines showed six per cent of the clusters free from mildew, the mixture containing seventy-five per cent sulfur showed ninety-six percent free, that containing fifty per cent showed eighty-three per cent free and that containing twenty-five per cent showed twenty-seven per cent free. The seventy-five per cent mixture caused severe burning, the fifty per cent mixture a small amount of burning and the twenty-five per cent mixture slight burning.

The aecial stage of Coleosporium elephantopodis. GEO. G. HEDGCOCK and W. H. LONG

Young trees of *Pinus heterophylla* in the greenhouse at Washington, D. C., were inoculated under controlled conditions in November, 1915, with the teliospores of *Coleosporium elephantopodis* (Schw.) Thüm. In February, 1916, the aecia of *Peridermium carneum* (Bosc.) Seym. and Earle appeared on the needles in abundance.

These were fully mature late in March. Inoculations with the aeciospores March 7 and April 5, 1916, on the leaves of plants of *Elephantopus tomentosus* L. produced in abundance the characteristic uredinia and telia of *Coleosporium elephantopodis*.

During the past three years parallel sets of inoculations of plants of Vernonia on the one hand and of Elephantopus on the other with the aecia of *Peridermium carneum* from a number of species of pine have resulted in producing *Colesoporium vernoniæ* B. and C. on the former, and C. *elephantopodis* on the latter, indicating the identity of the two species.

Peridermium carneum is now reported for the first time on the needles of *Pinus caribæa* Morel., *P. clausa* (Engelm.) Sarg., *P. echinata* Mill., *P. glabra* Walt., *P. heterophylla* (Ell.) Sudw., *P. ponderosa* Laws., *P. rigida* Mill., *P. scopulorum* (Engelm.) Lemm., and *P. serotina* Michx.

The Peridermium belonging to Coleosporium ipomœæ. GEORGE G. HEDGCOCK and N. REX HUNT

Peridermium ipomœæ a new foliicolus species on *Pinus echinata* Mill., *P. palustris* Mill., *P. rigida* Mill., and *P. taeda* L. is described, with a range from Pensylvania to Florida and Texas.

Plants of *Ipomœa lacunosa* L., *I. pandurata* L., *I. triloba* L., *Pharbitis barbigera* (Sims.) G. Don., *P. hederacea* (L.) Choisy, and *Quamoclit coccinea* (L.) Moench under controlled conditions were successfully inoculated with the aeciospores of this Peridermium, producing on their foliage the typical uredinia and telia of *Coleosporium ipomœæ* (Schw.) Burrill, thus proving that it is the aecial stage of this Coleosporium. Plants of species of Amsonia, Aster, Calonyction, Chrysopsis, Convolvulus, Coreopsis, Elephantopus, Helianthus, Laciniaria, Silphium, Solidago, Verbesina and Vernonia were unsuccessfully inoculated.

Coleosporium ipomœæ is now reported for the first time on the leaves of *Ipomolea caroliniana* Pursh., *I. trifida* (H. B. K.) G. Don., and *Pharbitis barbigera.*

A Peridermium belonging to Coleosporium terebinthinaceæ. GEO. G. HEDGCOCK and N. REX HUNT

Peridermium terebinthinaceum, a new foliicolus species on *Pinus echinata* Mill., *P. rigida* Mill., and *P. taeda* L., is described with a range from North Carolina to Georgia.

Inoculations were made under controlled conditions with the aeciospores of this Peridermium on plants of *Silphium asteriscus* L., *S. integrifolium* Michx., *S. trifoliatum* L. and *Parthenium integrifolium* L. in May and June 1916. In about two weeks the uredinia, and later the telia of *Colesporium terebinthinaceæ* (Schw.) Arthur appeared on the leaves of all these species, proving the Peridermium to be the aecial stage of this Coleosporium. Inoculations were made at the same time on plants of species of Amsonia, Coreopsis and Laciniaria without result.

Coleosporium terebinthinaceæ is now reported for the first time on the leaves of *Silphium angustum* (A. Gray) Small, *S. compositum* Michx., *S. dentatum* Ell., *S. glabrum* Eggert, and *S. pinnatifidum* Ell.

An alternate form for Coleosporium helianthi. GEORGE G. HEDGCOCK and N. REX HUNT

A new foliicolus species, *Peridermium helianthi,* is described on *Pinus virginiana* Mill., with a range from Pennsylvania to South Carolina and Tennessee. Inoculations made with the aeciospores of the Peridermium, under controlled conditions,

on plants of *Helianthus decapetalus* L., *H. divaricatus* L., *H. giganteus* L., *H. glaucus* Small, and *H. hirsutus* Raf. produced the uredinia and telia of *Coleosporium helianthi* (Schw.) Arthur, usually in abundance, thus proving the Peridermium to be the aecial stage of this Coleosporium. Inoculations were made at the same time on plants of species of Aster, Chrysopsis, Coreopsis, Elephantopus, Laciniaria, Parthenium, Rudbeckia, Silphium, Solidago, Verbesina, and Vernonia with negative results. The results of these inoculations indicate that the Coleosporiums on Coreopsis and Verbesina are distinct from the one on Helianthus. The Coleosporium in Florida on Verbesina which has been assigned to *C. helianthi* may belong to one of the unnamed species of Peridermium found by the writers in the south.

Coleosporium helianthi is now reported for the first time on *Helianthus australis* Small, *H. divaricatus* L., *H. eggertii* Small, *H. glaucus* Small, *H. grosse-serratus* Martens, *H. hirsutus* Raf., *H. microcephalus* T. and G. ,and *H. saxicola* Small, and its range (on Helianthus) is extended to Louisiana and Florida.

Some new hosts for Coleosporium solidaginis. GEORGE G. HEDGCOCK and N. REX HUNT

Peridermium acicolum Underw. and Earle, the aecial stage of *Coleosporium solidaginis* (Schw.) Thüm., is reported for the first time on *Pinus caribaea* Morel., *P. contorta* Loud., *P. divaricata* (Ait.) Du Mont de Cours, *P. echinata* Mill., *P. elliottii* Engelm., *P. mayriana* Sudw., *P. nigra* Arnold (*P. laricio* Poir.), *P. nigra* var. *austriaca* Schneid., *P. palustris* Mill., *P. ponderosa* Laws., *P. scopulorum* (Engelm.) Lemm., *P. serotina* Michx., *P. taeda* L., and *P. thunbergii* Parl.

Positive results have been obtained from inoculations with the aeciospores of *Peridermium acicolum* on plants of species of Aster and Solidago, and negative results only, on plants of species of Campanula, Convolvulus, Coreopsis, Elephantopus, Eupatorium, Euthamia, Helianthus, Ipomoea, Laciniaria, Parthenium, Pharbitis, Senecio, Verbesina, and Vernonia. A Coleosporium on *Chrysopsis mariana* (L.) Nutt., found first by W. H. Long in Florida, is tentatively assigned to this species.

The range of the Peridermium has been extended to include nearly all States from Minnesota and New Hampshire on the north to Arkansas and Florida on the south.

Notes on some species of Coleosporium. GEORGE G. HEDGCOCK and N. REX HUNT

Coleosporium delicatulum Arth. and Kern is reported for the first time on *Euthamia caroliniana* (L.) Greene, and *E. leptocephala* (T. and G.) Greene, and *Peridermium delicatulum* (Arth. and Kern) Hedge. and Long for the first time on *Pinus caribea* Morel., *P. echinata* Mill., *P. elliottii* Engelm., *P. heterophylla* (Ell.) Sudw., *P. mayriana* Sudw., *P. palustris* Mill., *P. nigra* Arnold, *P. ponderosa* Laws., *P. resinosa* Ait., *P. serotina* Michx., and *P. taeda* L., and the range of the species is greatly extended.

Coleosporium laciniariæ Arth. is reported for the first time on *Laciniaria earlei* Greene, *L. elegans* (Walt.) Kuntze, *L. elongata* Greene, *L. paucifl*ora (Pursh) Kuntze, *L. scariosa* (L.) Hill, and *L. serotina* Greene, and the range of the species extended to Florida on the South and to New Jersey on the north.

Some new hosts for Coleosporium inconspicuum. GEORGE G. HEGDCOCK and N. REX HUNT

Aeciospores from *Peridermium inconspicuum* Long collected for the first time on the needles of *Pinus echinata* Mill. were successfully inoculated on the leaves of

both *Coreopsis major æmleri* (Ell.) Britton and *C. verticillata* L. resulting in the formation of the uredinia and tellia of *Coleosporium inconspicuum* (Long) Hedgc. and Long. Unsuccessful inoculations were made on plants of species of Amsonia, Aster, Chrysopsis, Elephantopus, Euthamia, Helianthus, Laciniaria, Silphium, Solidago, Verbesina, and Vernonia. The results of these inoculations indicate that *Coleosporium inconspicuum* is distinct from species found on plants of these genera. This Coleosporium is reported for the first time on *Coreopsis delphinifolia* Lam., *C. lanceolata* L., *C. major* Walt., *C. major rigida* (Nutt.) Boynton, and *C. tripteris* L.

Coleosporium apocynaceum Cooke has been collected at Clearwater, South Carolina on *Amsonia ciliate* Walt.

Scolecotrichum graminis on timothy, orchard grass, and other grasses. A. G. JOHNSON and C. W. HUNGERFORD

During the past few years *Scolecotrichum graminis* has been observed by the writers on timothy and orchard-grass at various points from Wisconsin to the Pacific Coast. The fungus causes a serious disease of these hosts especially in Wisconsin. The young lesions on the leaf are circular to elliptical in form, vary greatly in size, and are usually purplish brown in color, The older lesions turn grayish brown as the invaded tissues die. In severe cases they coalesce involving considerable portions of the leaf-blades. In the worst cases practically all of the leaves of affected plants are dried up at about flowering time. In moist weather the fungus sporulates abundantly on the older lesions. On orchard grass, the lesions are somewhat more distinctive and sporulation takes place more abundantly. The conidiophores come out through the stomata and form dark-colored tufts arranged rather regularly in rows.

Other grasses observed by the writers as hosts for the fungus are *Agrostis alba, Bromus marginatus, Bromus sitchensis, Hordeum jubatum, Hordeum nodosum, Elymus glaucus* and *Elymus robustus.*

Observations at Madison have shown that the fungus over-winters readily in tufts of orchard grass and timothy and resumes activity early in the spring.

Bacteria of barley blight seed-borne. L. R. JONES, A. G. JOHNSON, and C. S. REDDY

In further studies on the bacterial blight of barley, upon which reports have been previously made, the mode of overwintering of the causal organism and of its dissemination over long distances have received especial attention. Field evidence early indicated that in certain cases the disease doubtless was introduced with seed from various western sources. In following up this matter, seed was collected in 1914 from a field of barley in Montana severely affected by the blight. Lesions were evident on the glumes of these plants before maturity and showed, although less clearly, upon the ripe grain. Some of this seed was planted in our trial grounds in Wisconsin in 1915, and the blight developed abundantly upon the leaves of the young plants.

Isolation cultures were made in July, 1916, from the glumes of barley kernels from this same 1914 Montana collection. The characteristic barley blight organism was obtained and its pathogenicity proved by inoculation experiments. It is thus apparent that the organism may be carried with the seed grain and remains viable after at least two years of dormancy. Preliminary trials indicate that the organism may be destroyed by seed disinfection.

The Pseudopeziza leaf spot diseases of alfalfa and red clover. FRED REUEL JONES

The Pseudopeziza leaf spots of alfalfa and red clover have been studied for the past two years for the purpose of determining the following points.

1. Are the causal organisms the same or distinct species?
2. Is any other spore-form than the ascospore included in the life history of these fungi?
3. What is the relation of these fungi to the tissues of their hosts?
4. How do these fungi overwinter?
5. Can the occurrence of the alfalfa leaf spot on alfalfa sown in a new region for the first time be prevented by seed treatment?

Progress has been made as follows:

1. Both fungi have been obtained in pure culture. Slight morphological and distinct physiological differences have been found.
2. Only ascospores have been found produced in nature. Conidia-like structures occur in cultures.
3. Germinating ascospores penetrate the epidermal cells directly and the mycelium develops within the host cells and penetrates the cell walls.
4. The fungus overwinters on dead leaves which escape decay, and ascospores developed either in old or new apothecia are a source of spring infection.
5. Alfalfa seed very thoroughly disinfected has been sown at distances up to 15 miles from other alfalfa. Leaf spot has occurred on all these plots.

The development of the aecial stage of Nigredo on red clover. I. E. MELHUS and WILLIAM DIEHL

The occurrence of the uredino- and teliospore stages of *Nigredo fallens* (Desm.) Arthur (*Uromyces fallens* (Desm.) Kern) on red clover (*Trifolium pratense*) is common, but the aecial stage of this rust is apparently not well known. The uredinospore stage developed abundantly on red clover growing in the greenhouse beginning about January 10, 1916, when the clover plants were about six inches tall. These grew in pots forming a border nearest the glass on a bench in a house where the temperature ranged from 10° at night to 20°C. in the day time. On March 26, 1916, aecia were observed on the leaves of the red clover plants. During the next two weeks the aecial stage became abundant. It continued to develop for about a month when the temperature raised in the house due to the increased sunshine. White clover (*Trifolium repens*), alsike (*T. hybridum*), and crimson clover (*T. incarnatum*), growing in close proximity were continually free from infection.

Repeated attempts were made to transfer the rust to the above hosts by using the aeciospores but no infections were obtained except on the red clover. It would appear that *Nigredo fallens* is autoecious and not heteroecious as heretofore reported.

A malnutrition disease of the Irish potato and its control. H. A. EDSON and OSWALD SCHREINER

Beginning early in the past July, potato plants in numerous eastern fields from Maine to Virginia developed a downward curling of the leaf margins accompanied by a bronzing and later a browning but not a yellowing of the foliage. Death of the leaves and sudden collapse of the stems at the ground level followed. Fungi of parasitic habits appeared at and above the point of collapse. Dr. W. A. Orton observed the disease in New Jersey and noted its absence from areas treated with potash or stable manure. Similar observations were made elsewhere, particularly in Maine, where Dr. Joseph Rosenbaum and B. E. Brown and L. A. Hurst have

undertaken a study of the disease in cooperation with the Maine Agricultural Experiment Station. These investigations are incomplete but present indications are that the fungi isolated are weakling parasites operating as contributing factors and that the primary cause is malnutrition, resulting from insufficient potash or perhaps an excess of nitrates in the presence of a minimum potash supply. In Maine the disease appears to be correlated with certain soil types and is most marked on Irish cobbler, Bliss and Eureka, though not entirely restricted to these early varieties. Stable manure is an excellent corrective.

Notes on curly dwarf symptoms on Irish potatoes. W. L. DURRELL

Plants showing curly dwarf symptoms were very prevalent in Iowa this past season on the varieties Irish cobbler, Rural new yorker and Early ohio. In some cases these symptoms were on plants grown from the progeny of plants having shown curly dwarf symptoms the preceding year; in others they were induced by climatic conditions. The disease made its appearance on the early planting about June 10 and continued to develop throughout the season. In August, plants that had been normal up until that time, showed typical signs of curly dwarf on the foliage produced during this period. The upper third of the plant had shortened internodes, crinkled and curled leaves, giving this portion of the plant a bushy appearance so characteristic of curly dwarf. These symptoms were induced in the field by the hot dry weather during August and similar ones were later artificially developed in the laboratory. The plants manifesting these induced symptoms of curly dwarf put forth normal foliage again in September with the advent of cooler weather.

Histological studies show that the crinkling of the leaves is due to necrosis of certain epidermal and cortical cells of the veins, followed by the growth of the parenchyma cells which induces a buckling of the leaf surface. In addition the leaves showing curly dwarf symptoms were characterized by a most marked decrease from the normal in the size of the parenchyma cells. Furthermore transpiration tests using the cobalt chloride paper and potometer methods indicate that curly dwarf plants transpire more rapidly than normal ones.

Notes on mosaic symptoms of irish potatoes. I. E. MELHUS

The so-called mosaic disease of potatoes is characterized by yellow mottling and crinkling of the foliage. Its effect on the potato plant, transmissibility, and relation to curly dwarf is very imperfectly understood. The varieties of Bliss triumph and Green mountain, which showed mosaic symptoms in 1914 and 1915 in northern Maine, were planted in 1916 at Ames, Iowa. The characteristic yellow mottling typical of this disease did not develop at any time during the growing season. Curly dwarf symptoms, however, were prevailingly present.

(a) Plants seemingly badly affected in 1915 produced 0.237 pounds per hill.
(b) Plants seemingly moderately affected in 1915 produced 0.29 pounds per hill.
(c) Plants seemingly slightly affected in 1915 produced 0.32 pounds per hill.

Healthy plants used as checks produced 0.46 pounds per hill.

None of the plants in lots *a* or *b* grew as large as those in lot *c*, but some of the *c*-plants were like those of *a*. Although the typical mottling characteristic of mosaic in certain northern potato growing districts may not develop, the progeny of plants showing these symptoms are undesirable for seed purposes.

Frost necrosis of potato tubers. L. R. JONES and ERNEST BAILEY

A peculiar type of non-inheritable "net necrosis" of potato tubers has been under observation for several years under conditions suggesting frost injury. Carefully

repeated chilling experiments confirm this hypothesis. Tubers "frozen solid" are totally killed and collapse when thawed. If, however, the chilling stops with incipient ice-crystallization, killing may be confined to such interior tissues as are most sensitive. Such chilled tubers appear normal externally but when cut show the interior vascular regions to be most sensitive and hence the first to succumb and discolor. Therefore, moderate exposure to freezing temperature may produce either "ring" or "net" necrosis, the blackened vascular portions permeating the starchy fundamental tissues. Individual variations in sensitiveness occur between tubers, but in general the best types of "net necrosis" have been secured by about two hours exposure to +5°C., with similar results by exposures ranging from −1°C. for 8.5 hours to −9°C. for one hour. Slightly more severe treatments, or unequal exposures may give frozen spots with corresponding dark blotches involving the general parenchyma. The stem end of the tuber is always more sensitive than the other.

Will Spongospora subterranea prove serious in Virginia? J. A. MCCLINTOCK

Potatoes affected with powdery scab planted in Virginia in the spring of 1915 produced a crop free from this disease. In the spring of 1916 affected tubers from Maine were planted at Norfolk, Virginia, and at Tasley, on the Eastern Shore of Virginia. The writer examined the crop at each place but found no signs of Spongospora infection on any of the harvested tubers. Some of the infected seed from Maine was held over summer in cold storage and planted at Norfolk about the time the fall crop of Irish potatoes was planted in Virginia. On November 23, 1916, the tubers were harvested and examined but no Spongospora infection was observed. These results corroborate those of 1915 and lead one to conclude that powdery scab will not be prevalent either on the spring or fall planted potatoes even though the seed tubers are infected with *Spongospora subterranea*.

Seed potato certification in Nova Scotia. PAUL A. MURPHY

Many fields of Garnet chili potatoes for the Bermuda seed trade were infected to the extent of fifty per cent with leaf roll, and whole districts to not less than ten per cent, making a difficult situation when we took charge. Hill selection in districts proved useless in several cases tried. The scheme adopted had to be a comprehensive and unusual one, an outline of which follows.

It is necessary for growers to start with stock of good previous record. This provision, which is absolutely insisted on, is becoming more stringent, and in two years the growers will use exclusively stock which is now selected and is being given a three years' trial. Thereafter it will still be continuously selected, one man being appointed in each district to grow it for his neigbors.

The summer inspection is made jointly by officers of the Departments of Agriculture of Canada and Bermuda, while the autumn inspection is made by the Canadian authorities. The grower's name appears on each barrel, whereby many stocks are traced to the Bermuda plntations. As a further safeguard a sample of every grower's potatoes are sent to Bermuda, where they are all planted together.

The economic importance of mosaic of potato. PAUL A. MURPHY

The beginning of a series of experiments to investigate the economic importance of this disease has given striking results. In one experiment of eleven similar plots side by side, planted partly with healthy, and partly with mosaic-diseased Green mountains of the same strain, the diseased plants gave a yield which was on the

average only 57.8 per cent that of the normal plants, the limits being 52.0 per cent and 63.6 per cent. Furthermore the crop of the mosaic-diseased plants was marketable only to the extent of 82.7 per cent (limits, 74.1 and 87.3), while 91.6 per cent of the crop of the healthy plants was marketable (limits, 81.9 and 94.1). This means that in an average crop of 300 bushels there is a loss of one and one-third bushels of marketable potatoes for every 1 per cent of mosaic present. This coupled with the fact that the trouble is constant every year and that it generally affects, where present, not far from twenty per cent of the crop means a steady loss of from twenty to thirty bushels of potatoes per acre per year. The eating qualities of the potatoes are not impaired.

A new strain of Puccinia graminis. E. C. STAKMAN and F. J. PIEMEISEL

A rust which behaves differently from any of the common biologic forms of *Puccinia graminis* has recently been found on club wheat and a number of wild grasses. It resembles *P. graminis tritici* morphologically and parasitically more that it does any other biologic form. However, the common *Triticum vulgare* wheats which have been inoculated are highly resistant to it. Both *P. graminis tritici* and the new strain have a number of hosts in common, viz: *Triticum compactum*, Barley, *Agropyron smithii, Elymus canadensis, Elymus macounii,* and *Hordeum jubatum.* The new strain has also been found in nature on *Elymus glaucus* and *E. condensatus* and has infected a number of grasses in the greenhouse. Extensive cross-inoculation experiments are now under way.

The rust was found only west of the Rocky Mountains in Idaho and Washington where it seemed to take the place of ordinary *P. graminis tritici*, none of which was found in the region mentioned.

Puccinia graminis on wheat kernels and its relation to subsequent infection. CHAS. W. HUNGERFORD

Various workers have noted the occurrence of rust pustules on seeds of different grains and some have held that the fungus might infect the plant by this means. Experiments have been carried on at Madison, Wisconsin the last year to determine if possible whether *Puccinia graminis* is able to infect wheat through the seed. Three lines of attack have been followed. (a) Rusted seed after being germinated at different temperatures has been fixed and examined by histological methods and in no case was the fungus found to penetrate the embryonic tissues. (b) Treated and untreated samples of rusted seed, as well as clean seed, were planted in the field and the first appearance of stem rust upon the plants in the different plots was noted at practically the same time. (c) Two lots of rust-infected seed have been grown to maturity in an isolated room in the greenhouse. No rust has appeared on any of these plants. Although the work has not been fully completed, the results so far tend to show that seed wheat infected with *Puccinia graminis* does not cause infection of the wheat plant.

Similar experiments are being started at Corvallis, Oregon, with wheat infected with *Puccinia glumarum.*

Ecological observations on Ustilago Zeae. ALDEN A. POTTER and LEO E. MELCHERS

Pammel and Stewart in 1893 observed that the nodal buds of maize were particularly subject to smut and that "where one smut boil made its appearance on the lower nodes, others appeared further up." It thus becomes desirable to explain how the infection, shown by Brefeld to be strictly local in its development, can spread on the plant. The basis of study has been Brefeld's idea of distribution by

air-borne conidia. The organism has been isolated in pure, conidial culture, both from the air and from the young plants some little time before the disease appeared. The corn plant is thus seen to be well adapted as a spore trap. The conidia caught probably do not infect directly. The result is rather the development of a virulent culture in the leaf axil. A plant may thus become a center of aerial distribution; or, when rain recurs, the conidia may be washed down or splashed out upon other leaves. Thus it may sometimes happen that all the culms of a plant, or hill, will show many nodal infections when an equal number of stalks immediately adjacent will not be infected at all.

The short-cycled Uromyces of North America. G. R. BISBY

Only eleven species of short-cycled Uromyces have been found in North America. These rusts are parasitic upon six families of Monocotyledons and Dicotyledons. Various relationships are evident between these rusts and other long-cycled and short-cycled species of rusts. Seven species are commonly micro-forms; for four of these, pycnia are known. Seven species have strictly local mycelium. These rusts occur mainly in Western and Southern North America. The specimens have been studied at the Arthur Herbarium.

Boleti and mycorhiza upon forest trees and an unusual mycorhiza upon white oak. L. H. PENNINGTON

One instance of a Boletus, *B. speciosus* Frost, connected with mycorhiza of oak was reported in 1908. Since that time five other species, *B. frostii* Russell, *B. indesisus* Pk. *B. chromapes* Frost, *B. purpureus* Fr. and *B. gracilis* Pk. have been found connected with mycorhiza of forest trees, usually oaks. Two of these species, *B. frostii* and *B. indecisus*, have been found to produce sclerotia similar to those reported for *B. speciosus*.

A peculiar form of mycorhiza was found upon white-oak roots in which the hypertrophied branches are closely aggregated and surrounded by a peridium-like layer of fungal tissue. This gives them the appearance of white root tubercles, four to twelve millimeters in diameter. These tubercle-like growths are not unlike those upon beech roots described in 1899 by Von Schrenk. They are also definitely connected with small sclerotia from which there is a growth of mycelium in early summer to produce new mycorhiza upon the roots. Attempts to inoculate the roots of other trees with this fungus have thus far failed.

A new parasitic slime mold suitable for class work. JOHN A. ELLIOTT

The sweet potato "pox" organism, *Cystospora batata* Elliott, as it occurs on sweet potatoes, offers itself as an excellent example of the Plasmodiophorales for use in the laboratory. Infected plants growing between sheets of moist blotting paper afford an abundance of parasitized rootlets and growing points of stems for free-hand sectioning or for embedding in paraffin. Such material is easily sectioned and contains great numbers of the parasite in all stages of its life cycle. The rapidity with which the organism goes through its complete life history makes a study of living material of special value.

Strains of Rhizoctonia. J. ROSENBAUM and M. SHAPAVALOV

During the summer of 1916 a strain of Rhizoctonia was isolated from potato stems which showed a girdling and hollowing at or near the surface of the ground. This

strain, designated R 5, differs in the following particulars from other strains isolated from stems and tubers of potatoes grown in Maine and Florida:

(1) Inoculations with R 5 produced definite lesions in injured potato stems growing in the field and greenhouse and injured tubers, while in the case of inoculations with other strains the lesions, if produced at all, were smaller and the results not so conclusive. The injured checks remained healthy.

(2) Macroscopically R 5 can be distinguished by the darker coloration of the medium, especially when grown on potato agar, and by the light grayish sclerotia as compared with the dark-brown sclerotia of the others when grown on corn-meal agar.

(3) Microscopically R 5 differs from the other strains in its finer mycelium, which measures 5 to 9 μ in diameter while the others measure 10 to 14 μ.

Is it not possible that different strains of Rhizoctonia may offer an explanation for the conflicting reports regarding artificial infection?

The aecial stage of the red clover rust. W. H. DAVIS and A. G. JOHNSON

The well known red clover rust, *Uromyces fallens* (Desm.) Kern, has long been suspected of having an aecial stage. Our observations and experiments have thrown definite light on the question.

Aecia on red clover were first obtained experimentally in the greenhouse in December 1915 and similarly again in January and February, 1916. Later in the spring a number of cases of aecia were observed on the same host out of doors near Madison. Following various sowings of aeciospores from such sources on rust-free red clover plants under glass, uredinospores developed uniformly. These were identical with those commonly observed on that host. Sowings of viable teliospores resulted in the development of aecia, identical with those observed in greenhouse and field.

It is thus evident that this rust is a long-cycled autoecious species, i.e., with pycnia, aecia, uredinia and telia on the same host.

Observations on pear blight in Illinois. F. L. STEVENS, W. A. RUTH, G. L. PELTIER, and J. R. MALLOCH

Experiments made by applying *Bacillus amylovorous* in suspension in water to pear buds in 1915 did not indicate in 1916 that the bacilli hibernated in the buds.

Subcuticular infections of spurs from hold-over trunk cankers occurred in 1916, with a maximum number of twelve such infections from one canker. The organism appeared to be dead in all twig cankers. A few living cankers provided exudate for serious well-distributed blossom infection, which in turn provided exudate for further infections, these continuing until early in June.

Leaves appeared to be at no time naturally infected from the exterior and on June 1 blades and pedicles could not be inoculated though the fruit and pedicles were still susceptible. Bordeaux mixture controlled the floral infection without reducing the set of fruit.

Second progress report on investigations of leaf spot of cherries and plums in Wisconsin. G. W. KEITT

Comparative studies of *Coccomyces hiemalis* Higgins and related organisms in connection with leaf spot diseases of cherries and plums have been continued, and spraying and sanitation experiments in the control of cherry leaf spot have been begun. Only the control work is reported here.

Spraying (Montmorency and Early Richmond). In early summer, the disease occurred in unusual severity, but, after the advent of hot dry weather in late July,

it made relatively little progress. It was satisfactorily controlled by Bordeaux mixture, 4–4–50, 3–3–50, and 2–2–50, and lime-sulphur (commercial concentrate, 33°B.), 1–40, applied (1) when the petals fell, (2) 16–17 days later, and (3) just after the fruit was harvested. "Atomic sulphur," 5–50; barium-sulphur, 3–50; and self-boiled lime-sulphur, 8–8–50, in parallel applications, did not control the disease satisfactorily. An additional application just before the blossoms opened did not increase the efficiency of leaf spot control.

Sanitation. Life history studies, sanitation experiments, and extensive observations indicate that, under Wisconsin conditions, the spray schedule may be strongly reinforced by turning under the fallen leaves as completely as feasible by clean cultivation before the blossoms open (In 1916, the first ascospore discharge was observed as cherry blossoms began to open).

Jonathan spot. CHARLES BROOKS and J. S. COLLEY

The development of Jonathan spot increases with an increase in temperature up to 20°C., but is entirely inhibited at 30°C. The disease can be readily produced in saturated air in closed moist chambers but seldom develops in a stirred air of 70 per cent or 95 per cent relative humidity.

Temperature relations of apple rot fungi. CHARLES BROOKS and J. S. COLLEY

Most apple-rot fungi will grow at a lower temperature on corn meal agar than on fruit and at a lower temperature on ripe fruit than on green fruit. With several if not all of the storage-rot fungi the initial stages of rotting are more inhibited by low temperatures than is the germination of the spores. Rots may finally make a fairly rapid development at temperatures at which the fungus is at first barely able to make a start. Even at favorable temperatures most of the fungi pass through a period of incubation on apples that is not evident on culture media.

Control of apple scab by bleaching powder. W. S. BROCK and W. A. RUTH

Bleaching powder when applied to apple trees in 1916 reduced apple scab from 50 per cent to 11.2 per cent. No injury resulted to fruit or foliage. The leaves on trees sprayed with this material were practically free from scab. Leaves on unsprayed trees showed serious scab infection.

In 1910 the material was applied at high concentrations alone, and with lime, causing little foliage injury, but no scab developed. Higher concentrations alone and in combination with other materials will be tried.

Studies on peach yellows and little peach. M. A. BLAKE, MEL. T. COOK and C. A. SCHWARZE

Symptoms very similar to peach yellows and little peach may be due to other causes. Tests with healthy and diseased trees showed (1) pulp from healthy leaves retains original color longer than pulp from diseased leaves; (2) juice from healthy leaves is more mucilaginous than that from diseased leaves; (3) juice from fast-growing trees more mucilaginous than juice from the leaves of slow-growing trees; (4) leaves taken from healthy trees after sunset showed a minimum amount of starch, leaves from little peach trees a larger amount, and leaves from yellows trees and from girdled trees the greatest amount; (5) leaves from an apparently healthy branch adjacent to a diseased branch on same tree showed a higher starch content than leaves from a healthy tree; (7) leaves from fast-growing trees lose starch more rapidly than leaves from slow-growing trees; (8) juice extracted from healthy

leaves showed less oxidase than juice from diseased leaves; (9) juice from healthy kernels showed less catalase and acid than juice from diseased kernels; (10) the tannin content of healthy fruit is less than that of diseased or forced fruit.

Pits from diseased trees failed to germinate. Budding experiments with diseased buds indicate that the appearance of the disease in the young trees varies with source of bud wood.

A Xylaria root-rot of the apple. F. D. FROMME and H. E. THOMAS

A destructive root-rot of apple trees is prevalent in the chief orchard sections of Virginia. The infectiousness of this condition is shown in the death of adjoining trees in groups irrespective of soil conditions or topography, and in the death of replants set in holes from which diseased trees were removed. Isolations from affected roots from a number of orchards have yielded cultures of a fungus which is apparently the conidial stage of a species of Xylaria. Perithecial stromata of *Xylaria polymorpha* have been found on roots of apple trees showing typical attack. Typical root-rot lesions have been produced with pure cultures of the Xylaria introduced into bark wounds of living apple roots in damp chambers and in the field. The introduced fungus has been recovered in pure culture from these lesions. Two or more species of Xylaria may be involved; their interrelations are subject for further study. Apparently all varieties of apples are susceptible and probably equally so. Observations indicate that the organism may be spread in cultivation, in the removal of borers, in contact between root systems of adjoining trees and in surface washing of infective material.

Pycnial scars, an important diagnostic character for the white pine blister rust. REGINALD H. COLLEY

After the pycnospores appear in their characteristic sweetish drops the whole pycnium is cut out by a protective layer of tissue which forms at a depth of several cells below the pycnial layer. Everything above the protective layer drys out and dies. The result of this drying is a rusty brown patch or scar which indicates by its size the extent of the pycnium. The scars are dark brown and glossy at first. Later they become rusty brown with a dry dusty-granular surface. They average about four millimeters in diameter. Pycnial scars are a positive diagnostic field character for the white pine blister rust, here reported for the first time. They are especially valuable when the bark is but little swollen, and when there is no indication of aecia or of aecial scars.

Mycelium of the white pine blister rust. REGINALD H. COLLEY

The uninucleate mycelium of *Cronartium ribicola* forces its way between the bark cells of white pine, frequently forming strands. As the cells are forced apart the bark swells. Haustoria penetrate practically every non-woody cell in the infected tissue. The sieve tubes become plugged. Hyphae follow the ray cells past the cambium and into the wood for a distance of at least three annual rings. Thus the fungus derives nourishment from both the ascending and descending currents of sap. The morphological characters of the mycelium are definite and constant under all conditions observed. Therefore the mycelium has positive diagnostic value for the blister rust before there is any exterior indication of spore formation.

The binucleate mycelium in Ribes leaves is limited in extent. Haustoria are rare. Uredinia and telia form quickly and burst through the epidermis easily.

The binucleate mycelium is very abundant in cases of petiole infection and the haustoria are larger and more numerous than in the lamina. Normal telia are usually produced but sometimes they are formed internally.

A species of Chrysomyxa new to North America. H. S. JACKSON

The genus Chrysomyxa was established in 1840 by Unger with *C. abietis* (Wallr.) Ung. as the type species, and has generally been interpreted as including both long and short cycle forms. Arthur restricted this genus to include only the microforms and established Melampsoropsis (Schröt.) Arth. for those species with a long life cycle. All of the latter forms are assumed to be heteroecious and have their uredinia and telia on Pyrolaceae, Ericaceae and Vacciniaceae. The aecial stages so far as determined, have proved to be species of Peridermium on Picea. In America eight species have been reported, all of which are long cycle forms and are referred to Melampsoropsis by Arthur. Four of these have been definitely connected through cultures by European and American students with their aecial stages.

A short cycle form referable to the genus Chrysomyxa (as restricted by Arthur) is recognized in America for the first time and causes a disease of the leaves of *Picea engelmannii*.

A Gnomonia on eggplant. C. W. EDGERTON

During the past three years, a species of Gnomonia has been found on old eggplant stems during the winter season at Baton Rouge, Louisiana. This fungus has been repeatedly cultured and it has been found to be very similar, if not identical, from a morphological standpoint, with the fungus causing the eggplant blight, *Phyllosticta hortorum*. The oval Phyllostieta spores and the long narrow Phlyctaena spores developed in culture. Cultures of the Gnomonia and cultures of *Phyllosticta hortorum* cannot be told apart. Inoculation experiments, however, have always been negative. While it may be that the Gnomonia has no connection with the Phyllosticta, it is very probable that the two are closely related species.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY AND FLORENCE P. SMITH, ASSISTANT

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[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals. All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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Uromyces striatus Schrœt; *Pseudopeziza medicaginis* [Lib.] Sacc.; *Phyllosticta* sp; *Pleosphærulina briosiana* Pollacci; *Peronospora trifoliorum* De By; *Rhizoctonia violaceæ* Tul; *Pseudomonas medicaginis*; yellow top; stem cracking (*Phoma* sp.).

Errata note: Upon statement of the author, the genus Phomopsis, p. 339 and 349, should read Phoma.

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